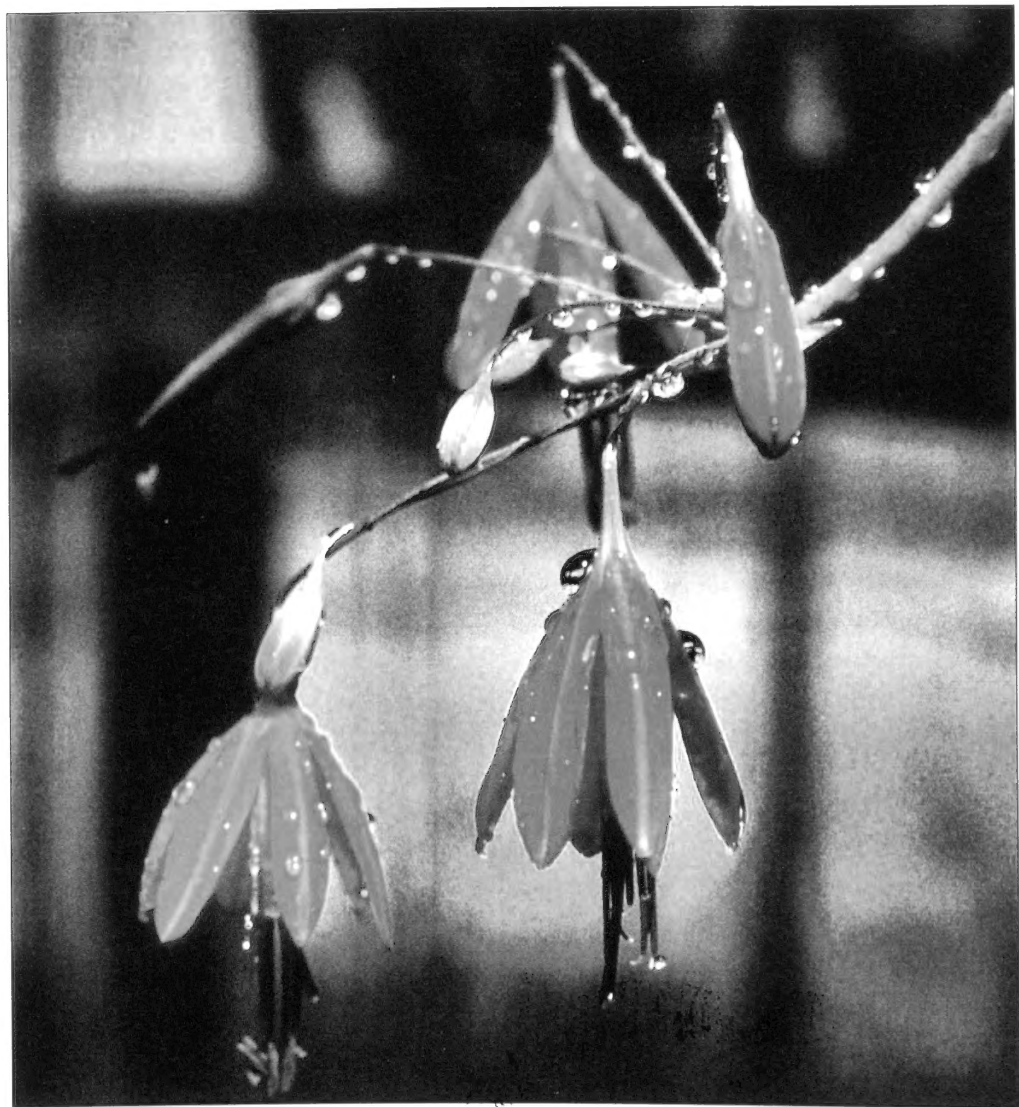

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VOLUME 55

2000



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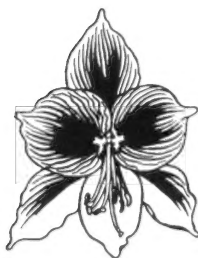
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EDITOR'S NOTES

Welcome to volume 55 (2000) of *HERBERTIA*, journal of the International Bulb Society. We are working diligently to get *HERBERTIA* back on normal publication phase so that the volume for a given year appears in the year of title. If all goes well, we will manage to get volume 56 (2001) just under this self-imposed deadline.

This issue of *HERBERTIA* contains a wonderful constellation of diverse fare: articles on *Calochortus*, *Corydalis*, *Eucomis*, *Rhodohypoxis*, *Siphonochilus*, *Triteleia*, as well as the customary amaryllid articles. *HERBERTIA* cannot thrive without high quality contributions, and it gives me particular pleasure to continue to receive such from a broad diversity of specialists of varying stripe. I also thank Dee Snijman, Rachel Saunders, Dave Lehmler and J. Chris Pires for each reviewing manuscripts that were submitted for both this volume and the previous.

Congratulations to our Herbert Medalists for 2000, Drs. August DeHertogh and David Lehmler. Dr. DeHertogh may be a new name for many members of IBS, but his contributions to the physiology and horticulture of geophytic plants are enormous, and he is well known throughout the commercial bulb industry in America and abroad. Dr. Lehmler, IBS board member, is being recognized for his studious work on the genus *Crinum*. A hearty round of applause for our first Traub Awardee, former IBS President Charles "Kingman" Hardman who recently began a new career as a singer/songwriter and has released his first CD.

At this writing, as spring begins to unwind across the Northern Hemisphere, a motif of rebirth comes to mind. In the gardens of many IBS members, the splendor of spring bulbs no doubt provides a renaissance of spirit. Much like its iconic plants, The International Bulb Society has seen its own cycles of trial and tribulation, and continues to blossom out of the fertile earth of its past history.

Please note that the final deadline for submissions for volume 56 (2001) of *HERBERTIA* is November 1, 2001.

—Alan W. Meerow, Editor

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As a member of the **INTERNATIONAL BULB SOCIETY** you will receive the following yearly benefits:

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Participation in occasional rare bulb sales. This will permit members to obtain rare and desirable species not available anywhere else.

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HERBERTIA

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CORRIGENDA

Editor's Note: The following tables were unfortunately omitted from the article on *Hymenocallis henryae* during the printing of HERBERTIA volume 54 (1999).

***HYMENOCALLIS HENRYAE*, A RARE ENDEMIC OF
THE FLORIDA PANHANDLE**

Gerald L. Smith

High Point University, High Point, NC

Josephine de N. Henry

Henry Foundation for Botanical Research

Table 1. Quantitative leaf characteristics of *Hymenocallis henryae* populations.

County	Character	N	Range		Mean		S.D.	
			L	W	L	W	L	W
Liberty	Leaf							
	Dimensions	73	30.0-59.0	1.9-2.9	49.5	2.3	6.45	0.26
Bay	Leaf							
	Dimensions	20	20.5-64.0	0.8-3.2	48.9	1.9	9.59	0.76
Walton (Before)	Leaf							
	Dimensions	34	29.5-67.0	1.5-3.2	52.3	2.2	8.68	0.47
Walton (After)	Leaf							
	Dimensions	55	30.5-58.3	1.0-2.2	42.1	1.5	5.10	0.24

N = sample size, L = length, W = width; all measurements are given in cm.

Table 2. One way ANOVA of leaf dimensions among plants of *H. henryae* from Liberty, Bay, and Walton Cos. (before and after disturbance)

Character	F Value	p Value
Leaf Length	18.871	.000
Leaf Width	57.536	.000

Table 3. T-Test of independent sample means of leaf dimensions between plants of *H. henryae* from Liberty Co. and Walton Co. (before disturbance).

Character	t-Test Value	p Value
Leaf Length	1.653	.105
Leaf Width	.545	.588

Table 4. T-Test of independent sample means of leaf dimensions between plants of *H. henryae* from Walton Co. (before disturbance and after disturbance).

Character	t-Test Value	p Value
Leaf Length	6.243	.000
Leaf Width	8.654	.000

Table 5. One way ANOVA of tepal length among plants of *H. henryae* from Liberty, Bay, and Walton Cos. (before and after disturbance)

Character	F Value	p Value
Sepal Length	6.334	.001
Petal Length	1.969	.129

THE HERBERT MEDAL



The Herbert Medal is the highest honor that the International Bulb Society can bestow upon a person for meritorious achievement in advancing the knowledge of bulbous plants. The medal is named for William Herbert (1778-1847), son of Henry Herbert, Earl of Carnarvon. William Herbert had a predilection for amaryllids and achieved success in their hybridization. He published his research findings in several monumental works. His contributions as a pioneer geneticist and plant breeder, and his arrangement of the Amaryllidaceae, helped set the stage upon which other workers, both amateur and professional, have been able to advance.

The award includes honorary life membership in the Society.

The Herbert Medal may be awarded annually or on special occasions by the Board of Directors of the Society. Medalists need not be members of the Society to be considered for the Herbert Medal.

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 Mr. Harry Blossfeld, Brazil, 1979
 Mr. Charles D. Cothran, California, 1980
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 Walter & Hilda Latapie, Louisiana, 1982
 Mrs. A. C. Pickard, Texas, 1982
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 Dr. Hamilton P. Traub, California, 1985
 Dr. Thomas W. Whitaker, California, 1988
 Mr. Grant E. Mitsch, Oregon, 1988
 Mr. L. S. Hannibal, California, 1988
 Dr. H. Shuichi Hirao, Japan, 1990
 Dr. Kenneth E. Mann, California, 1991
 Mr. Brian Mathew, England, 1992
 Dr. Maurice Boussard, France, 1996
 Sir Peter Smithers, Switzerland, 1997
 Dr. Dierdre Snijman, South Africa, 1997
 Dr. Alan W. Meerow, Florida, U.S.A. 1998
 Mr. Fred Meyer, California, 1999
 Dr. Peter Goldblatt, Oregon, 1999

2000 HERBERT MEDALIST AUGUST A. DE HERTOGH



First and foremost, I express my gratitude to the International Bulb Society for presenting me with "The Herbert Medal." The name William Herbert is synonymous with flower bulbs (geophytes). I am deeply honored to be a recipient, especially when one looks at the previous recipients.

My involvement with research on geophytes started in August 1965. How I reached this significant milestone in my career is directly due to the influence of my parents, Frank Joseph De Hertogh and Marie Louise

Van Cauwenbergh. They were born, raised, and married in Belgium. Subsequently, they immigrated to the U.S. in 1925 and 1926, respectively. From them, and especially my father, I learned many things. Career-wise, three of them have significantly impacted my career. First, there was the hard-work ethic. Being immigrants, who came with very little, they made their life through hard work. Second, being Belgians, they had an appreciation for agriculture. We always had a garden producing fresh fruit, vegetables, and flowers. During World War II, we lived in Chicago and almost the entire yard was a "Victory Garden." Later, we had 10 acres in Lemont, Illinois and a 100 acre tobacco farm in Ontario, Canada. It was this farm that caused me to go to N.C. State University to study. Education is the third and most important aspect, which they fully supported. Thus, when Dr. Thurston Mann, my undergraduate advisor, asked me in my Freshman year, "Would I consider going to Graduate School," my father said "Go for it, an education is something you'll never lose." Therefore, the farm was sold and I ultimately obtained my M.S. degree at N.C. State University under Dr. Glenn Klingman and my Ph.D. degree at Oregon State University under Dr. Harold Evans. I am indebted to these outstanding scientists not only for their excellent education guidance but also their philosophies regarding science.

I must return to my 1965 involvement with flower bulbs. At that time, the Dutch Bulb Exporters Association had contracted with Michigan State University to undertake a five-year research program on Dutch-grown flower bulbs. I had been hired to conduct post-harvest physiology on veg-

etables. However, Dr. Sylvan Wittwer, who was to head the bulb research program, left the Department in July to become the Director of the Michigan Agricultural Experiment Station. Thus, a project leader was needed. Dr. John Carew asked me to head this program and I accepted. I am forever indebted to him for this opportunity. Thanks to him, flower bulbs have become a lifetime obsession.

I also want to acknowledge and thank the approximately 150 co-workers who have been an integral part of the flower bulb research program I have headed. Without their efforts, the program could not have been successful. It is impossible to name all the individuals involved, but most of them are cited in my various publications, particularly the *Holland Bulb Forcer's Guide* and the *Physiology of Flower Bulbs*, co-edited with Marcel Le Nard. A special thanks, however, is due to Dr. Louis Aung and Mr. Jan van den Hoek who assisted in establishing the program in 1965. We had an excellent start and this contributed greatly to the success of the program. I also want to express my gratitude to Dr. Marcel Le Nard, my long-time colleague in France. His efforts have contributed greatly to the advancement of flower bulb physiology and tulip breeding (see above). Lastly, thanks to the many supporters of my research program. Some provided funds while others provided services. All of them, however, contributed greatly.

Lastly, I thank my wife Mary Belle, and the children who not only supported me but also very often provided "Free Labor." Their greatest benefit from my efforts has been to introduce them to the "World of Flower Bulbs" and the many wonderful people who are involved in it. They have enriched our lives beyond words. I thank all of them.

CURRICULUM VITAE

Higher Education

- B.S. North Carolina State University, Raleigh, North Carolina in 1957
(Field Crops)
- M.S. North Carolina State University, Raleigh, North Carolina in 1961
(Field Crops with major in Weed Science under the direction of Dr. G.C. Klingman)
- Ph.D. Oregon State University, Corvallis, Oregon in 1963
(Botany with major in Plant Physiology under the direction of Dr. H.J. Evans)

Professional Employment

- 1959-61: Graduate Research Assistant, North Carolina State University, Raleigh, North Carolina
- 1961 (June-August): Research Associate, North Carolina State University, Raleigh, North Carolina

1961-64: Graduate Research Assistant, Oregon State University, Corvallis, Oregon
1964-65: Assistant Plant Physiologist at Boyce Thompson Institute for Plant Research, Yonkers, New York.
March 16 to June 30, 1965: Visiting Lecturer in the Department of Biological Sciences at Hunter College in New York
1965-69: Assistant Professor of Horticulture, Michigan State University, East Lansing, Michigan
1969-72: Associate Professor of Horticulture, Michigan State University, East Lansing, Michigan
1972-78: Professor of Horticulture, Michigan State University, East Lansing, Michigan
1978-88: Professor and Head, Department of Horticultural Science, North Carolina State University, Raleigh, North Carolina
1988-2000: Professor of Horticultural Science, NC State University, Raleigh, North Carolina
2000-present: Research Coordinator, American Floral Endowment and Professor Emeritus, North Carolina State University

Professional Societies

American Society for Horticultural Science; Review Editor, The Journal 1973-76; Associate Editor, HortScience 1973-76; Publications Committee 1974-78; Cross-Commodity Director 1980-81; Advisory Council 1982-86, Chairman 1985-86; Resolutions Committee 1983-85, Chairman 1985; Vice President for Research 1986-87; Horticultural Reviews Editorial Board 1985; Fellows Committee 1987-91, Chairman 1988-89; Ad Hoc Committee on Dormancy 1987-88; Young Members Leadership Roles Committee, Chairman 1988; Southern Region American Society for Horticultural Science; Executive Committee 1987-92, Chairman 1992; Society of American Florists; Research Committee, 1991-95, Chairman 94/95; Research Committee, 1999-2000, Chairman 99/00; International Society for Horticultural Science; Sigma Xi; International Bulb Society

Honorary Societies

Gamma Sigma Delta; Phi Kappa Phi; Pi Alpha Xi; Sigma Iota Rho

Awards

1968 Meritorious Service Award from Michigan State Florists Association
1976 Alex Laurie Award from American Society for Horticultural Science
1981 Fellow of the American Society for Horticultural Science
1985 Medal of Honor, Ministry of Agriculture and Fisheries, The Hague, The Netherlands
1988 Professor De Hertogh Hyacinth Named by C. J. Ruigrok and Sons, De Zilk, The Netherlands
1988 Floriculture Hall of Fame Award from Society of American Florists
1988 Research Fellowship (Oct. 15 to Dec. 16) from Japan Society for Promotion of Science
1988 Featured in Triangle Profile in News and Observer (October 13, 1988)
1989 Award for Agricultural Excellence from Carolinas-Virginia Chapter of National Agricultural Marketing Association

- 1989 Certificate of Merit from Gamma Sigma Delta
- 1989 Futura Award from Professional Plant Growers Association
- 1990 Golden Pin Award from Dutch Bulb Exporters Association, Hillegom, The Netherlands
- 1990 Nicolaas Dames Golden Medal from Nicolaas Dames Foundation, Hillegom, The Netherlands
- 1991 Honorary Membership in Garden Writers Association of America
- 1992 Innovator Award from North Carolina State University for Development of Geophyte™ Software Program
- 1992 Teaching Award from American Horticulture Society
- 1994 Alex Laurie Research and Education Award from Society of American Florists
- 1996 Silver Tulip Award from International Flower Bulb Centre, Hillegom, The Netherlands
- 1997 Bulb Booster Award from North American Flowerbulb Wholesalers Association, Middletown, New Jersey
- 1997 Horticultural Initiative Award, Board of Directors of the Southeast Greenhouse Conference
- 1998 Special Appreciation Award, Northwest Bulb Growers Association, Mt. Vernon, Washington
- 1999 Special Appreciation Award, Israeli Bulb Growers, Tel Aviv, Israel

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2000 HERBERT MEDALIST DAVID J. LEHMILLER

AUTOBIOGRAPHY

My grandfather's garden had no equal. He literally spoiled us with an endless array of luscious vegetables and berries. Every fall he would gather his grandchildren together for outings into the woods to collect fall mushrooms and walnuts. Although he only resided a half mile away, it seemed that whenever he visited my mother, he brought food with him—including rabbits and pheasants during the winter hunting season. He even brewed a thick, syrupy plum wine.

I was born in 1940 and grew up in a small rural town in northeast Ohio. From early childhood, I can still recall my parents maintaining a garden that encompassed a one-acre lot adjacent to our home. Rows of sweet corn stand out in my memories. With the end of rationing following World War II, my parents abandoned the one-acre garden in favor of a small plot, and at age seven or eight, I eagerly became caretaker of the miniature vegetable garden. There was no doubt that I had inherited my grandfather's genes. The garden remained a personal project until I departed for college.

I graduated with a B.S. in Physics Engineering from the US Naval Academy and entered the US Air Force as a second lieutenant in 1962. After a two-year stint in graduate school at the University of Michigan where I earned a M.S. in Astrophysics, I was assigned to the US Air Force School of Aerospace Medicine in San Antonio, Texas. I worked alongside ophthalmol-

ogists and optometrists in a research unit whose mission was to provide eye protection for pilots against lasers and nuclear weapon flashes. A few years later, upon discovering a small program wherein the Air Force would sponsor active duty officers through medical school, I gained admission to the University of Texas Medical School at San Antonio. Nine years later, upon completing a residency training program at the Medical College of Georgia, I belatedly began a career as a pathologist in the Air Force. I



Dave Lehmillier collecting *Crinum distichum* with Forestry Officer Alexi and Forest Guide Edward near Sahr, Tchad.
Photograph by Darrel Plowes, 7 July, 1992.

remained in the Air Force until 1982, my last assignment being Department Chairman of Pathology at USAF Keesler Medical Center in Biloxi, Mississippi. I then accepted a private practice position in Beaumont, Texas, where I have remained ever since.

Other than my four years at the military academy and the subsequent two years of graduate school, I always managed to have a garden. In 1974, a friend presented me with a *Hippeastrum* bulb at Christmas, the common cultivar 'Appleblossom'. I was immensely pleased, and thereafter, I gradually acquired a few other commercially available *Hippeastrum*. When I moved to Beaumont in 1982, I probably had accumulated 40 assorted *Hippeastrum* bulbs plus a small contingent of common mail order bulbs, and I had already embarked upon crossing *Hippeastrum* and developing my own hybrids. It was then I decided that I wished to learn more about bulbs. I bought general purpose books on flower gardening, and I purchased a wider variety of bulbs from the fall 1982 catalogs. However, I wasn't satisfied with what I was accomplishing, and I sought to locate better sources of "unusual bulbs" and educational materials. However, since I had no acquaintances that were bulb enthusiasts, I floundered for lack of direction. Then I spied an advertisement in Texas Gardener by Marcia Wilson (a Herbert Medalist) of Brownsville, Texas, listing an assortment of bulbs including *Hippeastrum*. Upon receiving her catalog, I noted that she offered an assortment of *Crinum* species and hybrids, and the pictures in her catalog attracted my attention. Although I ordered a variety of bulbs from her, I specifically requested that she send me bulbs of two different *Crinum* species so that I might try my hand at hybridizing. She sent me large bulbs of *C.bulbispermum* and *C.moorei* (and a personal letter) that I received in the spring of 1983. These *Crinum* bulbs subsequently flowered, I cross pollinated them, and to my amazement, I was rewarded with an abundant cache of seed (it was actually an unusual form of *C.x powellii* var *alba*, as *C.moorei* var *schmidtii* was the seed parent and *C.bulbispermum* var *alba* the pollen donor.) Success! I eagerly submitted another order to Marcia requesting more *Crinum* bulbs, but no response was forthcoming. Marcia had died unexpectedly in the fall of 1983.

Now that I was familiar with general features of *Crinum*, I noticed plantings of *Crinum* hybrids in the old-town district of Beaumont, and I was soon able to make trades with several occupants by offering them *Hippeastrum* bulbs in return. I quickly learned that not only did the older districts in the Gulf Coast cities harbor *Crinum* plantings, but so did the old pauper cemeteries. I began to travel throughout the region on weekends,

carrying my shovel and a few pots of *Hippeastrum*, and my *Crinum* collection began to grow. However, I simply cannot explain why I became so obsessed with this genus.

In the early spring of 1984, I discovered a small advertisement by the American Amaryllis Society, sent in the \$10. Membership fee, and soon the 1983 issue of *Herbertia* arrived. I was shocked. Here were articles about *Crinum*! For my birthday in July, 1984, I purchased the entire *Herbertia* library—now I had plenty of educational materials to peruse. Much to my surprise, I gleaned that a Society member from Beaumont, Mrs. Shirley, had written several articles in *Herbertia* circa 1963-65 on *C. americanum* and the Neches River. So I began to search near the bayous of the Neches River for *C. americanum*, but I had no success. My oldest son, who was then a student at Lamar University in Beaumont, purchased a fishing boat in May, 1985, and I asked him to take me for a boat ride on the Neches River so that I might look for *C. americanum*. We launched the boat adjacent to the Beaumont Country Club and traveled north on the Neches River. After several miles we arrived at the Pine Island Bayou and the Big Thicket Nature Preserve, and I spotted a colony of bulbs along the shoreline. Other sightings quickly followed. I was instantly infatuated. Soon thereafter, I purchased a small, flat-bottom boat, a nine horsepower outboard motor, and "frog poles" for navigating over fallen trees. In July, 1985, I commenced a detailed investigation of *C. americanum*. During the next 18 months, I made >60 trips into the cypress swamps, bayous, and old logging channels of the Neches River, compiling the data and observations for my first *Herbertia* publication in 1987.

The *Herbertia* library also provided me with names and addresses of authors, and I sought out *Crinum* enthusiasts in the American Plant Life Society with whom I could correspond. I also became a Life Member in the Society. In 1985 I met Thad Howard (a Herbert Medalist) and began a friendship that eventually culminated in joint field trips to Mexico and Guatemala. Thad became my teacher. Not only was he knowledgeable about *Crinum*, but Thad was also the premier hybridizer of *Crinum*, being the first to develop and market a series of complex hybrids. It was Thad who instilled into me the importance of making detailed observations of living plants—in the manner of Thad's idol, William Herbert. Indeed, Herbert's *Amaryllidaceae* was the first professional book to enter my botanical library.

Through a quirk in the tax laws, I acquired an unexpected sum of money in 1986, and thereupon I decided to undertake a field collecting trip to Africa. I had been impressed with Verdoorn's account of *Crinum* in

Southern Africa, so I chose to visit South Africa and South West Africa (now Namibia), thinking that perhaps I could locate some of the collection sites listed in Verdoorn's article. I knew absolutely no one in South Africa when I arrived in January, 1987, but I rented a car in Johannesburg and set out on my own for four weeks of cross-country driving. It was during the height of the communist insurrections in both South Africa and Namibia, and although I passed through many military roadblocks and was searched many times, I was too excited about observing bulbs in the wild to become dismayed. I must remark that I was treated with such gracious hospitality during my travels in South Africa that I was frankly embarrassed—an uninvited foreign stranger requesting assistance in locating native flowers would have been viewed with suspicion in my country. In my estimation, South Africa was certainly the most beautiful place in the world, but it was to the remote semi-desert country of Namibia where I was drawn—here were vast regions of poorly explored territories, hiding untold botanical secrets. Searching for Namibian *Crinum* in the bush, in localities where "tourists" never strayed, made me feel like I was akin to Henry Morton Stanley. I was brash and reckless, being totally oblivious to the ongoing-armed conflict; I drove roads into regions where land mines were reported.

Having considered my field trip to Africa as the most exciting as well as fascinating experience of my life, I could not help but return to South Africa and Namibia the following year and the next year. During my third trip, I became acquainted with Dave Hardy, a senior research horticulturist at the National Botanical Institute in Pretoria, and subsequently the two of us experienced seven wonderful field trips to Namibia, Botswana, Zambia, and Madagascar. My wife, Nancy, accompanied us to Zambia as I wished for her to see Victoria Falls. I also had two occasions to collect *Crinum* in Tchad and Cameroun, thanks to Darrel Plowes and Anita Mackey, plus a short visit to Ethiopia. Twelve times I crossed the Atlantic Ocean to collect in Africa.

The African trips and contacts provided me with a wealth of *Crinum* species never before introduced into hybridizing endeavors. A listing of hybrids that I have flowered is provided below, and all save one are still under cultivation. Those with commercial trade names are so noted. Sadly, some of the most exotic productions are unique bulbs that have shown no propensity to offset, and they remain cloistered in my greenhouse. My hybridizing efforts are continuing as I write, with at least 50 new crosses yet to achieve flowering size. I cannot explain why I have pursued hybridizing with such persistence and vigor. Hybridizing is not my true passion—rather it is field collecting in Africa and the associated taxonomic investigations into

speciation that motivate me the most. God willing, and my health permitting, I plan to visit the wilds of Africa until I can only do so in my dreams.

I am very honored to receive the Herbert Medal. My botanical achievements are solely the result of my association with the International Bulb Society. I am equally honored to have been appointed to the Board of Directors, a service which I consider as an opportunity for me to repay the Society for what it has given to me.

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Crinum Hybrids (seed parent/female listed first)

F-1 Interspecific Hybrids

- C. americanum* x *C. japonicum* = 'Mike's Choice'
- C. americanum* x *C. lugardiae*
- C. americanum* x *C. macowanii*
- C. americanum* x *C. moorei* = 'Pink Perfume'
- C. asiaticum* x *C. moorei* = 'Sal Gal'
- C. baumii* x *C. lugardiae*
- C. bulbispermum* x *C. asiaticum* (red leaf)
- C. bulbispermum* x *C. carolo-schmidtii*
- C. bulbispermum* x *C. fimbriatulum* = 'Herbertia Plus'
- C. bulbispermum* x *C. lugardiae* = 'Nathan Daniel'
- C. bulbispermum* x *C. macowanii*
- C. bulbispermum* x *C. moorei*
- C. bulbispermum* x *C. paludosum* = 'White Bouquet'
- C. carolo-schmidtii* x *C. graminicola*
- C. carolo-schmidtii* x *C. moorei* = 'Ms. Nancy'
- C. carolo-schmidtii* x *C. oliganthum*
- C. carolo-schmidtii* x *C. scabrum*
- C. carolo-schmidtii* x *C. verdoorniae*
- C. erubescens* x *C. bulbispermum* = 'Long Shot'
- C. erubescens* x *C. scabrum* = 'Joshua's Jewel'
- C. flaccidum* x *C. americanum* = 'Lil' Stinker'
- C. flaccidum* x *C. lugardiae*
- C. flaccidum* x *C. moorei* = 'Peachy Keen'
- C. flaccidum* x *C. paludosum*
- C. fimbriatulum* x *C. scabrum*
- C. kirkii* x *C. graminicola*
- C. kirkii* x *C. zeylanicum*
- C. lineare* x *C. forbesii*
- C. lineare* x *C. macowanii*
- C. lugardiae* x *C. americanum* = 'Little Lugger'
- C. lugardiae* x *C. buphanoides*
- C. lugardiae* x *C. carolo-schmidtii*
- C. lugardiae* x *C. erubescens* = 'Big Lugger'
- C. lugardiae* x *C. fimbriatulum* = 'Lullaby'

- C. lugardiae* x *C. graminicola*
C. lugardiae x *C. macowanii*
C. lugardiae x *C. moorei*
C. lugardiae x *C. oliganthum*
C. lugardiae x *C. paludosum*
C. lugardiae x *C. scabrum* = 'Peppermint Candy II'
C. lugardiae x *C. subcernuum*
C. lugardiae x *C. zeylanicum*
C. macowanii x *C. acaule*
C. macowanii x *C. graminicola*
C. macowanii x *C. paludosum*
C. macowanii x *C. alba* = 'John Erich'
C. mauritianum x *C. erubescens* = 'Mr. Channel'
C. mauritianum x *C. fimbriatulum* = 'Mosess'
C. mauritianum x *C. moorei* = 'M&M'
C. moorei x *C. bulbispermum*
C. moorei x *C. lugardiae* = 'Namibian Pink'
C. paludosum x *C. americanum* = 'Bright Star'
C. paludosum x *C. erubescens* = 'Brighter Star'
C. paludosum x *C. fimbriatulum* = 'Polite'
C. paludosum x *C. forbesii*
C. paludosum x *C. kirkii*
C. paludosum x *C. macowanii*
C. paludosum x *C. moorei*
C. paludosum x *C. oliganthum*
C. paludosum x *C. rautanenianum*
C. paludosum x *C. scabrum*
C. paludosum x *C. variabile*
C. paludosum x *C. zeylanicum* = 'Beaumont Beau'
C. pauciflorum x *C. humilis*
C. politifolium x *C. americanum* = 'Papa'
C. politifolium x *C. asiaticum* (red leaf) = 'Red Slipper'
C. politifolium x *C. carolo-schmidtii*
C. politifolium x *C. fimbriatulum*
C. politifolium x *C. kirkii*
C. politifolium x *C. lugardiae*
C. politifolium x *C. macowanii*
C. politifolium x *C. mauritianum* = 'True Sue'
C. politifolium x *C. moorei* = 'Peculiar Pink'
C. politifolium x *C. oliganthum*
C. politifolium x *C. paludosum*
C. politifolium x *C. subcernuum*
C. politifolium x *C. zeylanicum* = 'Debbie's Delight'
C. procerum x *C. moorei* = 'Tall Star'
C. procerum x *C. scabrum*
C. rautanenianum x *C. americanum*
C. rautanenianum x *C. fimbriatulum*
C. rautanenianum x *C. forbesii*

C. rautanenianum x *C. lugardiae*
C. rautanenianum x *C. macowanii* = 'Rare Bird'
C. rautanenianum x *C. moorei* = 'Patricia Hardy'
C. rautanenianum x *C. oliganthum*
C. scabrum x *C. asiaticum* = 'Exotica'
C. scabrum x *C. asiaticum* (red leaf)
C. scabrum x *C. graminicola*
C. scabrum x *C. lugardiae* = 'Peppermint Candy'
C. scabrum x *C. zeylanicum* = 'Fancy Pants'
C. variable x *C. erubescens* = 'Veronica'
C. variable x *C. lineare* = 'Strictly Feminine'
C. variable x *C. macowanii*
C. variable x *C. moorei* = 'Peyton's Place'
C. variable x *C. scabrum* = 'Evan's Dream'
C. verdoorniae x *C. erubescens* = 'Pale Girl'
C. verdoorniae x *C. kirkii*
C. verdoorniae x *C. politifolium* = 'Mama'
C. verdoorniae x *C. zeylanicum*
C. yuccaeides x *C. broussonetii*
C. zeylanicum x *C. fimbriatulum*

F-1 Backcrosses

C. bulbispermum x (*C. bulbispermum* x *C. asiaticum*)
C. bulbispermum x (*C. bulbispermum* x *C. subcernuum*)
C. bulbispermum x (*C. moorei* x *C. bulbispermum*) = 'Norma Justine'
C. macowanii x (*C. forbesii* x *C. macowanii*)
C. politifolium x (*C. politifolium* x *C. asiaticum*)
C. scabrum x (*C. erubescens* x *C. scabrum*)
C. scabrum x (*C. scabrum* x *C. zeylanicum*)

F-2 Interspecific Hybrids

C. bulbispermum x (*C. americanum* x *C. moorei*) = 'Bambino'
C. bulbispermum x (*C. americanum* x *C. moorei*) = 'Pink Flamingo'
C. bulbispermum x (*C. forbesii* x *C. macowanii*)
(*C. bulbispermum* x *C. lugardiae*) x *C. graminicola*
(*C. bulbispermum* x *C. lugardiae*) x *C. kirkii*
(*C. bulbispermum* x *C. paludosum*) x *C. carolo-schmidtii*
(*C. bulbispermum* x *C. paludosum*) x *C. forbesii*
C. carolo-schmidtii x (*C. americanum* x *C. macowanii*)
C. carolo-schmidtii x (*C. variable* x *C. erubescens*) = 'Caronica'
(*C. forbesii* x *C. macowanii*) x *C. acaule*
(*C. forbesii* x *C. macowanii*) x *C. flaccidum*
(*C. forbesii* x *C. macowanii*) x *C. moorei*
C. lugardiae x (*C. americanum* x *C. moorei*)
C. lugardiae x (*C. forbesii* x *C. macowanii*)
C. macowanii x (*C. lugardiae* x *C. harmsii*)
C. macowanii x (*C. variable* x *C. moorei*) = 'Peyton's Daddy'

- C. paludosum* x (*C. americanum* x *C. moorei*)
C. paludosum x (*C. bulbispermum* x *C. moorei*)
C. paludosum x (*C. flaccidum* x *C. americanum*) = 'John's Bid'
C. paludosum x (*C. lugardiae* x *C. scabrum*) = 'Crisscross'
C. politifolium x (*C. bulbispermum* x *C. moorei*) = 'Alice Elizabeth'
C. politifolium x (*C. forbesii* x *C. macowanii*)
C. rautanenianum x (*C. paludosum* x *C. macowanii*)
C. scabrum x (*C. mauritanum* x *C. fimbriatulum*) = 'Cortes'
C. variabile x (*C. americanum* x *C. moorei*) = 'Vale'
C. variabile x (*C. moorei* x *C. bulbispermum*) = 'Kristin's Best Tan'
C. variabile x (*C. lugardiae* x *C. erubescens*)
C. verdoorniae x (*C. moorei* x *C. lugardiae*)

Complex Hybrids—3 Species

- [*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. graminicola* = 'Zan Gypsy'
 [*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. mauritanum*
 [*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. paludosum* = 'Gregor's Granny'
 [*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. paludosum* x
 C. moorei
 (*C. bulbispermum* x *C. paludosum*) x (*C. paludosum* x *C. lugardiae*)
 [(*C. forbesii* x *C. macowanii*) x *C. moorei*] x *C. forbesii*

Complex Hybrids—4 Species

- <[*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. graminicola*> x
 (*C. rautanenianum* x *C. moorei*) = 'Five Star'

Complex Hybrids—5 Species

- <[*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. graminicola*> x
 (*C. forbesii* x *C. macowanii*)
 <[*C. bulbispermum* x (*C. moorei* x *C. bulbispermum*)] x *C. paludosum*> x
 (*C. forbesii* x *C. macowanii*)

Complex Hybrids—Unknown Parentage:

- C. carolo-schmidtii* x 'Circus' = 'Citation'
 (*C. forbesii* x *C. macowanii*) x 'Circus'
 (Note: 'Circus' was developed by Thad M. Howard; it was reported to be 'Carnival' x
 Burbank's 'White Queen'. The parentage of Burbank's 'White Queen' is not known
 with certainty. See *Herbertia* 39:66-78, 1983.)

Intergeneric Hybrids With *Ammocharis* (x*Crimocharis*):

- A. nerinoides* x *C. baumii* = x*Crimocharis hardyi*
 (*A. nerinoides* x *C. baumii*) x *A. nerinoides*
A. nerinoides x *C. lugardiae*
C. baumii x *A. coranica*

THE HAMILTON P. TRAUB AWARD FOR DISTINGUISHED SERVICE

This award was established in 2000 by the IBS Board of Directors to recognize meritorious service to the Society. It is named after Dr. Hamilton P. Traub, founder of the American Plant Life Society, antecedent of IBS, and editor of its journal for a half century.

2000 TRAUB AWARD WINNER CHARLES E. HARDMAN



In 1988 Charles E. Hardman became a member of the Board of Directors of the American Plant Life Society (predecessor of the International Bulb Society). In 1994, he was elected to the role of President and for nearly five years worked in that position through some of the most difficult times

that the Society has ever endured. During that tumultuous period, which included a major embezzlement scandal, the Board managed to continue publishing *HERBERTIA*, the International Bulb Society's annual journal, and started *The Underground*, a twice-annual newsletter dedicated to the less formal aspects of bulbs, corms, rhizomes and tubers. An inveterate collector of bulbous plants, with a passion for all plants and a wonderfully positive attitude about life in general, Charles is a fitting first recipient of the Traub Medal for Distinguished Service. An autobiography of Charles will appear in a future issue of *BULBS*, the Society's quarterly magazine.

A REVIEW OF *CALOCHORTUS* SECTION¹ *CYCLOBOTHRA* (CALOCHORTACEAE)

Hugh P. McDonald, Ph.D.
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See pages 81–83 for color plates.

Calochortus is a genus of approximately sixty-five perennial, bulbous herbs, either classified as part of the Liliaceae, or treated as part or sole member of a distinct family, Calochortaceae (Patterson, 1998; Tamura, 1998; Rudall et al., 2000). The newest evidence is that *Calochortus* constitute a distinct family intermediate between Liliaceae and other, Asian families (Patterson, 1998). The family is confined to Western North America, from southwest Canada to Northern Guatemala, and from California to the Dakotas. A single basal leaf distinguishes the family, which is all that appears during most of the growing season. A stem with or without branches and with cauline leaves and bracts appears near the end of the season and culminates in one or more nodding or erect flowers. The petals are larger than the sepals in all but one species. They occupy virtually every one of the many habitats of the West. The plant is dormant for part of the year, corresponding to either a dry or cold season. *Calochortus* were well known to the Native American tribes of the area and used by them as a food source. Nurseryman Carl Purdy, who would dig the bulbs from the wild and ship them around the world, first popularized *Calochortus* as garden subjects at the turn of the century. The inability of the bulbs collected in the wild to survive in inhospitable climates led to an undeserved reputation for being difficult to grow, even in their home states, and their popularity declined.

The last major revision of *Calochortus* section *Cyclobothra* was published by Ownbey (1940). *Calochortus ownbeyi* is named in honor of this botanist whose monograph of the genus is unexcelled, before or since. Since then, several new species have been published and fresh material has become available. Ownbey's work was carefully prepared, but suffered from a lack of fresh material and, in some cases, ancient, depauperate herbarium specimens. The specimens that he was able to examine were in some cases so poor that he was unable to determine the shape of the nectary, a crucial

¹ N.B.: I am following Ownbey and subsequent botanists in delineating sections and subsections. Since the former genus is now a family, the former sections may now become genera, and the former subsections, sections. This has been proposed by Hoover. However, I am merely speculating on this point; at present they remain sections and subsections. Determination of these relationships will have to await more work on the family as a whole, to which I hope the present work is a contribution.

character for classifying *Calochortus*. With the aid of fresh material and living plants, certain new conclusions can be drawn and a new classification of the species within the subsection can be made.

Of the California members of sect. *Cyclobothra*, *Calochortus tiburonensis* (Fig. 1) was unknown to Ownbey. Hill (1973) suggested affinities of this species to section *Calochortus*, especially *C. tolmiei*. This connection is quite dubious. *C. tiburonensis* shares the fibrous-reticulate bulb coat, the late blooming habit, the larger stems and flowers and the upright, narrow capsules of the other California members of sect. *Cyclobothra*. Only its isolated northern range is unusual, but this is not uncommon in the family as a whole (cf. *C. westoni*, *C. macrocarpus*, and the northern stands of *C. splendens*, inter alia). *C. tiburonensis* is thus herein placed back in section *Cyclobothra*, and Ownbey's (1940) three subsections are thereby preserved.

The Mexican species of *Calochortus*, sect. *Cyclobothra*, fall into three subsections according to Ownbey (1940). Two of these subsections can be further divided into two additional subgroups, on grounds that will be explained below. A peculiarity of the Mexican species of sect. *Cyclobothra* is the production of leaf-axil bulbils in many species, sometimes in great quantity, during the growing season. However some of the group produce few or no bulbils. None of the other species in *Calochortus* are known to produce leaf-axil bulbils; in section *Mariposa* and in two species of section *Calochortus*, basal bulblets are produced. The production of leaf-axil bulbils is also characteristic of some species of *Lilium*. The subsection *Ghiesbreghtiani* is retained from Ownbey but has one new species, *C. ownbeyi*, (McDonald, Ness and Patterson, ined. and under review; Fig. 2). Another species has been removed from Ownbey's subsect. *Barbati* and placed with subsect. *Ghiesbreghtiani*. Ownbey thought *C. pringlei* (Fig. 3) was a nodding species, based on depauperate herbarium specimens, apparently missing Painter's (1911) correct description of it as upright. Field observations and horticultural treatment confirm its erect flowers. As these are small and hairy, they are properly placed with the *C. ghiesbreghtii* group. Subsection *Ghiesbreghtiani* contains two subgroups, based primarily on size and the degree to which the petals are covered by hairs or trichomes. One subgroup has flowers with relatively small petals, few hairs on the petals and little or no bulbil production. Two of this subgroup are alpine. This subgroup includes *Calochortus exilis*, *C. fuscus* (Fig. 4) and *C. venustus*. The other subgroup has hairier petals, slightly larger flowers and, except for one species, more generous bulbil production. This subgroup includes *C. ghiesbreghtii* (Fig. 5), *C. ownbeyi* (Fig. 2) and *C. pringlei* (Fig. 3). The fibrous-

reticulate bulb coat, small upright flowers, and summer growing season mark the new species in this subgroup, *C. ownbeyi*, as belonging to subsect. *Ghiesbreghtiani*, sect. *Cyclobothra*, as delimited by Ownbey (1940). *C. ownbeyi* (Fig. 2) is more bearded than three of the species of subsect. *Ghiesbreghtiani*, but, as with *C. ghiesbreghtii* (Fig. 5), its petal hairs are less thick and conspicuous than those of section *Barbati*, and do not extend to the upper part of the petals. In some of the inland, high-altitude populations, some specimens have larger, more appressed leaves and seem to produce fewer bulbils, but this is not a consistent character.

Calochortus ownbeyi (Fig. 2) has been confused with *C. venustulus* in some collections and also in some Floras, e.g. McVaugh (1983). The most striking differences are the tiny cauline leaves and bracts on many specimens of *Calochortus ownbeyi* and its very bulbiferous leaf axils, especially the populations from coastal Jalisco. The type of *C. ownbeyi* can be further distinguished from *C. venustulus* by its generally taller habit, more consistently branching stems, more spreading leaves and narrower, straighter nectary. Also, the hair-like growths or trichomes on the petals extend half-way or more up from the base of the petal and are white, while on *C. venustulus* they are limited to the nectary area and are yellow or reddish-brown. The lavender-colored anthers in some collections do not hold consistently; in some specimens, they are whitish. Those of *C. venustulus* are yellow. The petals of *C. venustulus* are yellow, while those of *C. ownbeyi* are white.

At the type location, *C. ownbeyi* grows in the broken shade of open pine and oak woods, with bunch grasses and a few other herbaceous perennials. *C. venustulus* has been observed in a similar habitat, for example near Temascaltepec, Mexico, but also grows at higher elevations in more exposed habitats with only pines. At such elevations *C. venustulus* is rarely branched, but this may reflect the shorter growing season and less fertile soils of its high mountain habitats. *C. venustulus* at lower elevations can be branched, although due to the smaller height of *C. venustulus* this may be less conspicuous. Thus the branching habit of *C. ownbeyi* may not be a distinguishing feature.

The characters which separate *Calochortus ownbeyi* from *C. venustulus* might seem to link the former with *C. ghiesbreghtii*. However, these species can be separated as well. *C. ghiesbreghtii* has reddish and yellow petal hairs, is rarely bulbiferous, and has a distinctive horseshoe-shaped nectary. Also, *C. ghiesbreghtii*, unlike *C. ownbeyi*, has nectary-like structures, or at least hair-like growths, on the sepals. Its eastern range also differs from that of *C. ownbeyi*, the range of which as now known lies exclusively in the Sierra Madre Occidental, from Jalisco to Chihuahua states.

Another species in this subsection, *C. exilis*, is also white, but seems to lack a nectary structure in all of the specimens which I have examined in the wild. It is also a much smaller plant, seemingly unbranched, and less bulbiliferous. Like *C. venustulus*, it has larger, fuller upper leaves and bracts, with a less spreading habit; and its petal hairs are confined to the base.

Calochortus fuscus [Fig. 4; "*C. hintoni*" in Ownbey (1940); see Ownbey's 1963 letter to H.H. Iltis in McVaugh (1983) for the nomenclatural correction], another species in the subsection, is occasionally bulbiliferous, but it produces nothing like the quantity of bulbils observed on many specimens of *C. ownbeyi*. Its larger upper leaves, dark red petal color and sagittate nectary further distinguish it. Again, its petal hairs are confined to the base in the nectary area.

Also belonging to this subsection is *C. pringlei* (Fig. 3), which, contra Ownbey (1940), has erect flowers. However, this species is consistently red and does not produce bulbils. Its petals are entirely covered with trichomes and its nectary is lunate. Its range is southeast of that of *C. ownbeyi*, in Mexico and Guerrero states. Because it is entirely covered with trichomes, it links subsect. *Ghiesbreghtiani* to subsect. *Barbati*.

The second subsection, *Barbati*, has narrow basal and cauline leaves, little or no bulbil production, nodding flowers and conspicuously hairy petals. This includes *C. barbatus*, *C. barbatus* var. *chihuahuensis* (Fig. 6) and *C. marcellae* (Fig. 7). *C. nigrescens* (Fig. 8), *C. pringlei* and *C. spatulatus* have been removed from this subsection as delimited by Ownbey.

Calochortus barbatus has three well-marked varieties. One occurs mostly in the western part of its large range. It is larger and all yellow. The other is more common to the east, is smaller, with petals that are purplish-brown on the outside and yellow on the inside. It has reduced upper leaves and produces more bulbils. It is distinct in these respects from var. *chihuahuensis*, which grows in NW Mexico, does not produce bulbils at all and is uniquely colored: purplish-brown on the upper exterior of the petals, but yellow on the lower portion. Because of the distinct range and characters of *C. barbatus* var. *chihuahuensis* (Fig. 6), it may be a distinct species, but at present is retained as a strongly marked variety.

The third subsection is *Purpurei*. The species in this subsection combine wide, amplexicaul cauline leaves with nodding flowers and significant bulbil production in all but one case. This section also has two subgroups. The first includes all the species in Ownbey's (1940) former subsect. *Purpurei* as he delineated it. The species in this subgroup have few petal hairs. It

includes *C. cernuus*, *C. foliosus*, *C. hartwegi* (Fig. 9) and *C. purpureus* (Fig. 10). *C. hartwegi* produces the fewest bulbils of this group, while *C. cernuus* has the narrowest leaves and hairiest petals, a possible link to the other subgroup and even to *Barbati*.

Finally, there is another subgroup that combines certain features of *Purpurei* and, to a smaller degree, *Barbati*. The species in this subgroup combine the wide amplexicaul cauline leaves and significant leaf-axil bulbil production of Ownbey's subsect. *Purpurei* with the hairy petals of subsect. *Barbati*. It includes *C. balsensis*, a species unknown to Ownbey, *C. nigrescens* (Fig. 8), and *C. spatulatus*. They form a subgroup that is intermediate in some respects between the other two subsections with nodding flowers, which make it difficult to separate Ownbey's two subsections. The new subgroup marks the gradation from the thin leaves and hairy petals of subsect. *Barbati* to the wide leaves and glabrous petals of subsect. *Purpurei*. However, the leaves are a clear mark of separation from *Barbati*, since hairy petals do not separate any of the subsections.

Ownbey placed two of the species of this new, intermediate subgroup in his subsect. *Barbati* and even thought that one, *Calochortus spatulatus* [*C. fuscus* in Ownbey (1940); see his letter to H.H. Iltis reprinted in McVaugh (1983) for the nomenclatural correction] was the most similar to *C. barbatus*. Apparently, he overlooked the wide cauline leaves of *C. spatulatus*, a feature with which he clearly identified subsect. *Purpurei*. As this species, along with *C. nigrescens* and *C. balsensis*, combines features of both of Ownbey's former subsections, it might seem best to combine all these species in one larger subsection. However, both observation of the plants and Ownbey's own procedure point in the opposite direction. *C. spatulatus* on casual acquaintance looks like a small *C. purpureus* and is difficult to separate from *C. cernuus* except by its hairier petals. All three species look identical prior to flowering, based on leaf morphology. *C. nigrescens* and *C. balsensis* also have the distinctive, wide amplexicaul cauline leaves and voluminous bulbil production of subsect. *Purpurei*. All three of the species in the new subgroup resemble those of the subsect. *Purpurei* group far more than subsect. *Barbati*, except for the hairier petals. As Dr. Tom Patterson (personal communication) has pointed out, leaf shape is a decisive feature in identifying sections in Ownbey (1940), and was used to separate the two other sections, *Calochortus* and *Mariposa*. The regrouping of the Mexican species of subgen. *Cyclobothra* in accordance with this feature seems justified.

Key to the sections of *Calochortus* and species of section *Cyclobothra*

1. Leaves grooved, generally withered by anthesis; habit medium to tall; flowers upright, campanulate; seeds straw colored, flat, ovoid(sect. *Mariposa*)
- 1'. Leaves flattened, generally persistent through anthesis, habit short to tall, flowers variable, upright to nodding; seeds darker, irregular.....2
 2. Bulbs with membranaceous coats; fruits wide, three winged, generally(sect. *Calochortus*)
 - 2'. Bulbs with fibrous-reticulate coats; fruits narrower, three angled,.....3 (sect. *Cyclobothra*)
3. Cauline leaves narrow, linear4
- 3'. Cauline leaves wider, lanceolate, amplexicaul; flowers nodding, most campanulate; some with nectary on sepals, some with contrasting color on sepals; capsules medium to large, thickened in middle, bloom August to October ..18 (subsect. *Purpurei*)
 4. Flowers upright, campanulate, inner surface covered by hair-like trichomes5
 - 4'. Flowers nodding, campanulate, inner surface conspicuously hairy, capsules medium thickened in middle, bloom August to October16 (subsect. *Barbatii*)
5. Plants tall; flowers large (except #1), spreading; petals with scattered hairs over most of the inner surface, never bulbiferous in leaf axils; capsules long, narrow, linear (exc. #2); bloom late May to late June (except #3)6 (subsect. *Weedii*)
- 5'. Bulbils in cauline leaf axils in most species, flowers small, spreading; petals usually without spot at base of petal hairs; nectary only slightly depressed, capsules small, thickened in middle, bloom August to October11(subsect. *Gliesbreghtiani*)
 6. Sepals often greatly exceed petals in length, nectary rounded or depressed7
 - 6'. Sepals about as long as petals, nectary rounded9
7. Flowers small, petal thickly covered with hairs, yellow and brown, nectary rounded, San Luis Obispo Co., California1. *C. obispoensis*
- 7'. Flowers large, cup shaped; petals often with spot at base of hairs; nectary depressed, not ciliate or rounded8
 8. Petals yellowish-green with purplish-brown bands; densely hairy near edge but not imbricate; nectary crescent-shaped; capsule medium, thickened in middle, Marin Co., California.....2. *C. tiburonensis*
 - 8'. Petals fringed with multiple rows of hairs (fimbriate); petals usually mottled pink or red and white; nectary generally obovate; capsule narrow, blooms late July and August; Central Coast Ranges, California3. *C. fimbriatus*
9. Petals fringed in single row, usually yellowish, some with brown marks and blotches; some with serrated edges; bloom May and June; S. Coast and Peninsular Ranges, California4. *C. weedii* (Var. *intermedius*, which has paler, but also frequently with purplish upper, petals occurs in the Coast Ranges of Orange Co., Ca.).
- 9'. Petals not fringed10
 10. Petals pale yellow, often serrated at edge; Peninsular Ranges, N. Baja5. *C. weedii* var. *peninsularis*

- 10'. Petals pink, lavender or purple, not serrated at edge; Transverse and N. Peninsular Ranges, California.....6. *C. plummerae*
11. Plants usually taller, more spreading; sepals about equal to petals; petals thickly covered with hairs over half the inner surface12
- 11' Plants shorter, less spreading, petals hairy only at base in vicinity of nectary14
12. Cauline leaf axils not bulbiferous, petals hairy over entire surface, flowers red, nectary lunate, Transverse Ranges, Mexico7. *C. pringlei*
- 12'. Bulbiferous in cauline leaf axils; petals less thickly hairy, usually only on lower half13
13. Cauline leaves medium, with few bulbils; some with greenish sepals; petals white to very pale yellow; nectary on both sepals and petals, horseshoe shaped; Sierra Madre Oriental Mexico to Guatemala8. *C. ghiesbreghtii*
- 13' Cauline leaves usually short, frequently very bulbiferous; some sepals pale lavender; petals white; nectary linear, vertical, W. Jalisco, Mexico to Chihuahua9. *C. ownbeyi*
14. Leaf axils not bulbiferous, petals yellow, nectary vertically oblong, N and C Sierra Madre Occidental, Mexico.....10. *C. venustus*
- 14' Leaf axils usually bulbiferous15
15. Nectary sagittate, petals dark red, sepals not reddish on exterior; Transverse Ranges, Mexico.....11. *C. fuscus*
- 15' Nectary lacking, petals white, sepals reddish on exterior, Sierra de Pachuca, Mexico12. *C. exilis*
16. Petals hairy above nectary on inner surface and fringed at edge; usually bulbiferous in cauline leaf axils; flowers purplish-red with yellow interiors; nectary slightly depressed, present on both sepals and petals, sagittate, ciliate; N. Sierra Madre Oriental, Mexico13. *C. marcellae*
- 16'. Petals hairy above and below nectary, nectary depressed, rounded17
17. Leaf axils bulbiferous; flowers large, yellow, some brown on exterior; petals obovate, serrate and fringed at edge; Transverse Ranges and surrounding Plateau south in Sierra Madres to Oaxaca14. *C. barbatus*
- 17' Leaf axils not bulbiferous; flowers smaller, brownish on lower part of outer side of petals and yellow on upper part and inner; petals ovate, less serrate or fimbriate at edge; N. Sierra Madre Occidental15. *C. barbatus* var. *chihuahuensis*
18. Petals partly or mostly covered with hairs19
- 18' Petals hairy mostly at edges, nectary not depressed21
19. Leaf axils moderately bulbiferous; nectary only slightly depressed, rounded; flowers very dark reddish purple; N. Oaxaca and Puebla18. *C. nigrescens*
- 19' Leaf axils very bulbiferous, nectary depressed20
20. Nectary round; flowers purplish brown, some with yellow or green streaks and blotches; some, yellow or green sepals; Transverse Ranges, Mexico16. *C. spatulatus*

- 20'. Nectary triangular; flowers globose, yellow, some with greenish sepals; Mts. of Oaxaca and Guerrero17. *C. balsensis*
21. Flowers larger, nectary not rounded22
- 21' Flowers smaller, nectary rounded23
22. Leaf axils less bulbiferous; flowers purplish with brown, green and yellow streaks and blotches; petals hairy on midveins and margins only; nectary sagittate to triangular; W. Mexico mostly in the Sierra Madre Occidental.....19. *C. hartwegi*
- 22' Leaf axils more bulbiferous; petal edges sparsely bearded, petals purple to brown with shading and mottling in green, yellow and other colors; nectary shaped like an ellipse bisected with a zigzag line ; Sierra Madre Occidental, Durango to Mexico20. *C. purpureus*
23. Cauline leaves narrower, shorter; petal edges more conspicuously bearded; flowers purplish-brown, Sierra de Tepoztlan, Morelos21. *C. cernuus*
- 23' Cauline leaves long and thick, petals sparsely bearded, purplish; S. Michoacan22. *C. foliosus*

***Calochortus fimbriatus* McDonald, sp. nov. (Fig. 11-12).**

TYPE: California: "Santa Barbara," Aug., 1902 (holotype: *Elmer* 3740 (UCB!); isotype: G! MO!).

Calochortus weedii var. *vestus* Purdy in Proceedings. Calif. Acad. Ser. III Bot. 2: 133, 1901.

Calochortus weedii var. *purpurascens* Watson in Proc. Am. Acad. 14: 265, 1879.

Bulbus ovoideus, tunicis fibroso-reticulatis. Caulus crassus, erectus, 3-5 dm, ramosus, folialia subtenta ramos varia late in longitudine, infimum saepe longum, superiora breviora. Folium basalum planum, linearum, attenuatum, 2-5 dm longitudine, 10-22 mm latitudine; folia caulina 2-6 dm longitudine, 10-22 mm latitudine, lanceolata aut angusta-lanceolata linearum. Plantae plerumque cum 2-4 floris, bracteis parisque adversis, angustis-lanceolatis vel linearis. Flores campanulati, erecti, aliquantum extentos; cum tres sepala alba, aut maculosa, alba et rubellus, lanceolata, apiculata, 7-12 cm. longitudine, 2-4 mm. latitudine, glabra, plerumque sine glandulis; tres petala alba aut saepe maculosa, albus et rubellus, 4-7 cm, triangulata vel obovata, facies interiora barbata proximo base ad 2/3 longitudine vel apice petalorum, pilis plurimis flavis et mixtus cum fusci pili, densissimus fimbriatus apice, pilosus rubris-fuscis et in duplico ordone. Glandula saepe obovata vel ovata, depressa. Filimenta dilatata a base, 4-5 mm longitudine, basi-certa; antherae rubri-fusci, oblongae, acutae ad apiculatas, 5-8 mm longitudine. Ovarium fusiformum, linearum, non alatum, 4-7

cm longum, stilus 2-4 cm. cum stigmatе persistente trifido 2-4 mm latitudine. Capsula erecta, apiculata, plus latius in media parte, 4-7 cm, cum tres locularum, dehisca ex apice deorsum; seminae planae, levis fuscis, leve margo, irregularae, 3-7 mm.

Bulb ovoid, with fibrous-reticulate coats. Stem stout, erect, 3-5 dm, branching, branches widely variable in length, lowest often long, upper much shorter. Basal leaf flat, linear, attenuate, 2-5 dm long, 10-22 mm wide; cauline leaves 2-6 dm long, 10-22 mm wide, lanceolate or narrow-lanceolate to linear. Plants usually with 2-4 flowers, bracts paired, opposite, narrow-lanceolate to linear. Flowers campanulate, erect to somewhat spreading; with three sepals, white or mottled white and reddish, lanceolate, apiculate, 7-12 cm long, 2-4 mm. wide at base, glabrous, nectaries generally absent; petals dun white or more often mottled white and reddish, 4-7 cm, triangular to obovate, inner face covered with trichomes from near base to 2/3 length or to top, hairs mostly yellow and mixed with some dark brown hairs; hairs most dense at petal edges, reddish-brown and in a double row; nectary oval to generally obovate. Filaments six, 4-5 mm long, dilated at base; anthers lanceolate to apiculate, 3-4 mm long. Style 2-4 cm long with persistent trifid stigma about 2-4 mm wide. Ovary linear, not winged, 4-7 cm long. Capsule erect, apiculate, slightly wider in mid-section, 4-7 cm long with 3 locules, generally dehisca from top down; seeds 3-7 mm long, irregular in shape, flattened, tan to light brown, with slight edge.

Ownbey thought *Calochortus fimbriatus* to be a variety of *C. weedii* (var. *vestus*) but it differs in so many respects that it should be raised to specific status. *C. weedii* is always yellow, even in its more genuine varietal forms, var. *peninsularis* (Fig. 13) and var. *intermedius* (Fig. 14; the latter is very pale yellow with purplish sepals on the exterior). The taxon Ownbey classified as *Calochortus weedii* var. *vestus* (*C. fimbriatus*) is never yellow but varies from an egg white to red but almost always with mottling of red or dark pink over white. *Calochortus weedii* is confined to the northern Peninsular Ranges from Riverside Co. to Northern Baja; *C. fimbriatus* is well to the north in Santa Barbara and Monterrey Counties in the Coast Ranges. *Calochortus weedii* blooms relatively early for this group, as early as late May at sea level; *C. fimbriatus* is notable for its extremely late bloom time, usually at the end of July into August. *C. weedii* has a single row of fimbriate hairs on the edge of the petals (the "fringe"); *C. fimbriatus*, always has a double row, which is very conspicuous and whose hairs are often twice as long as the smaller ones on *C. weedii*. *Calochortus fimbriatus* has longer sepals that,

like *C. obispoensis*, considerably exceed the petals in length; while those of *C. weedii* are shorter. Finally, *C. weedii* has a circular nectary while that of *C. fimbriatus* is usually obovate. Ownbey, writing his monograph as a doctoral candidate, tended to be deferential to previous botanists. He took too literally Carl Purdy's word for the continuity of the California members of sect. *Cyclobothra*, i.e., that they were varieties of one species. Thus he stated that the petals of *Calochortus fimbriatus* are "truncate," following Purdy, while in fact they are as large as those of *C. weedii* or *C. plummerae* and often rounded not squarish. It is unfortunate that he was unable, as far as I know, to see *C. fimbriatus* in the wild or as a living specimen. One look would convince any fresh observer, not burdened by the mistakes of past botanists, that *C. fimbriatus* is a separate species. The name "*fimbriatus*" as a specific difference marks one of the most prominent features of the new species, its conspicuous double row of fringed hairs on the edge of the petals.

ECOLOGY

Calochortus species bloom over a long season, from as early as March to as late as October in Mexico. California, like the other Pacific Coast states and provinces, has a Mediterranean type climate. This climate pattern is very much like that in the countries around the Mediterranean, parts of Chile, South Africa and Western Australia. Such climates are characterized by fairly mild, wet winters followed by hot, dry summers. Rainfall is moderate to heavy in winter and spring, but very sparse in summer. In California it almost never rains from mid-May to the end of October. The flowers bloom in spring, near the end of the rainy season, and then many go into dormancy for the long summer drought. Plants with bulbs, such as those of *Calochortus* section *Cyclobothra* are well suited for such climates. The bulb lives on underground over this long dry spell, with a food supply stored for new growth in late fall.

In Southern California, most flowers have come and gone in the lowlands by late June. It is dry; the rains are over. Why would any flower bloom? To take advantage of the reduced competition for pollinators! Flowers compete for the services of various insects that spread pollen from one plant to another. What better time to bloom than after most of the competition has passed from the scene, and the flower is the only show in town, so to speak? This is the seeming strategy of the California members of sect. *Cyclobothra*, a group of *Calochortus* that tend to bloom long after most of the other flowering plants in their habitat, including other *Calochortus*.

Their bulb, with its stored food, is able to send up a flower well after the rains have ceased. The plants wait for most of the competition to die down and then bloom, attracting pollinators with less trouble.

There are five species in this group. In the south is Weed's *Cyclobothra* (Figs. 13-14; *C. weedii*, sometimes referred to, inaccurately, as "Weed's Mariposa"), which grows from Orange county to Baja California, and from the seacoast to the mountains, mostly in chaparral areas. It generally blooms in late June. Although it grows on the windward side of the mountains it still encounters fairly dry conditions throughout most of its range. It is yellow, sometimes with brown markings, and with tiny hairs on the petals. The petals of this species are often wavy at the edge. The stem gets quite tall in order to grow up between the protective shrubs.

To the north, from Riverside to Ventura Counties, Plummer's *Cyclobothra* (Fig. 15; *C. plummerae*) grows in similar habitats at about the same time. It has a strikingly beautiful flower, which can be lavender, pink, rose, reddish or a deep purple. While it can more commonly be found on the windward sides of the mountains, a few stands grow on the leeward, on desert slopes. It is in danger of extinction due to the rapid development of the hills surrounding the Los Angeles Basin for homes.

Well to the north, in the hills surrounding the college town of San Luis Obispo, is the San Luis Obispo *Cyclobothra* (Fig. 16; *C. obispoensis*). It is a rare species with a small range. It looks like a Cat's Ear with enlarged sepals. The small petals are densely covered with hairs, while the sepals are larger and stick out prominently beyond the inner whorl. This gives the flowers what has been called a "bizarre" appearance. The flowers of this species are also yellow with brown markings. It is a chaparral endemic, on the windward side of the Coast Ranges, often growing up between the branches of protective shrubs.

In between Plummer's and the San Luis Obispo *Cyclobothras* grows a plant which is often considered to be a variety of Weed's Mariposa, but which I consider a distinct species. Although it resembles the plant to the south it is different in color. The flower can be white, red or combinations of the two, often with a mottling of red over white. Even more telling is the bloom time: late July and into August, long after Weed's *Cyclobothra* has gone to seed, and closer to the next rainy season than to the one past. There are other genera of bulbs that bloom just before the rainy season, rather than just after it, such as many Amaryllidaceae of South Africa's Western Cape. In species with this bloom pattern, the seed is set and ready for the

rains just as they arrive. They are less likely to be damaged or scorched by summer heat. This distinctive habit is evidence for recognition of the reddish-mottled plant from Santa Barbara and Monterey Counties as a distinct species, *C. fimbriatus* (Figs. 11-12), the Central Coast Cyclobothra. The plant grows at or near ridge tops where the seasonal rains are at their heaviest. On these ridges, it grows both in the full shade of oak woodlands and in full sun, mostly in sandstone. It is the last species of the year to bloom in California.

Another species related to the southern California Cyclobothras, although it grows in northern California, blooms in late June. The Tiburon Cyclobothra (Fig. 1; *C. tiburonensis*), a rare and endangered species, occupies a very small area in the middle of developed lands in Marin Co., just across the Golden Gate from San Francisco. This is a recently discovered species that was entirely missed by early botanists in an otherwise well-explored area. The flower is light brown with red, brown and yellow markings. The Nature Conservancy, a non-profit organization that conserves vital wild habitats by purchasing them, saved the land on which the plant grows from development. The Tiburon Cyclobothra would probably be extinct but for this effort. The species occupies a narrow, serpentine-laden, ridgetop overlooking San Pablo Bay, where, due to careful conservancy, it has slowly increased its numbers during the short time since it has become known.

The temperate climate zone does not stop at the U.S. border, but extends into Mexico. Climate is as much a function of altitude as of latitude. At higher altitudes, winter may be year round as it is on some of the higher peaks even at the equator. Much of Mexico consists of a medium-elevation plateau, bordered on the east, west and south by high mountain ranges. These ranges are named the Sierra Madre Occidental in the west and the Sierra Madre Oriental in the east. As one descends from the higher to the lower altitudes of Mexico, different plants and habitats are encountered. At the higher altitudes, the climate patterns are temperate, with four distinct seasons. At medium altitudes, including both the plateau country and in lower alpine habitats, the climate is subtropical, with cool, dry winters and warm, wet summers. At the lowest altitudes, which are in coastal areas, the climate is tropical, with a warm dry season and a hot, humid, rainy season. The rainy season occurs during the Northern Hemisphere summer and the dry season during the Northern Hemisphere winter. Due to this summer rainfall pattern, the species of Mexican Cyclobothras bloom later in the season than their U. S. and Canadian cousins, from August to October but pre-

dominantly in late September into early October.

There are two species that have adapted to the cold winters and wet, mild summers of the high mountains. These species receive winter snow, but, like other temperate species, are still in winter drought, as the water is not available for growth. One occurs at moderate to high elevations in the Sierra Madre Occidental and grows from Chihuahua in the North to the state of Mexico in the South, *C. venustulus*. It has a small yellow flower. The Tarahumara Indians, who live in the region of Northwest Mexico where it is most common, call the plant "*secate*." Its habitat is open conifer forests where it can get some sunlight, and also find pockets of mulch to in which to grow. These small, scattered pockets have built up from the decayed needles of the conifers and other plants trapped between the rocks in otherwise thin and poor soils. In the high mountains in which the plant is found, rainfall is often trapped year round from both the east and the west, although there is much more in summer.

The other species grows at high altitudes in the mountains of the East of Mexico. It is less frequently encountered than *C. venustulus*, but is structurally similar. It also grows in similar habitats, i.e. thin pockets of soil enriched with mulch on otherwise bare, montane summits. There it can enjoy moisture both from thunderstorms originating on the plateau country to the west, and tropical storms off the Caribbean whose moisture is lost as they surmount the peaks of the Sierra Madre Occidental. This is the Hidalgo Cyclobothra (*C. exilis*), named after the state in which the flower is found, which in turn honors a hero of the Mexican Revolution. It is white on the inside and on the exterior of the petals, with red sepals and small yellow hairs near the base.

On the leeward slopes to the west grow two species that have adapted to conditions created by the loss of wind borne moisture on the high peaks to the east. This is basically dry habitat; cacti are commonly encountered in the area. However, one of these species echoes the strategy of some California Mariposas and is a wet grower, taking advantage of seasonal streams running down the western slopes of the eastern mountains in the south central part of Mexico. The flower has an extremely dark, reddish-violet color, so dark that its botanical name, *C. nigrescens*, means Dark or Black Calochortus (Fig. 8). As with many of the Mexican Cyclobothras, the flower is inverted or nodding. Perhaps this keeps out the water during the occasional, torrential thunderstorms in the region. This species grows in or by small streams or in wet meadows created by runoff from seasonal rainfall

from the high peaks. It is similar to the habitat of Palmer's Mariposa in California, although the flora is quite different. The plant is found in both shade and sun. The range of the Black *Cyclobothra* lies in Pueblo and Oaxaca states. In this area, the winters are cool and dry while the summers are mild and wet.

To the north another species has adapted to the dry conditions on the leeward slopes of the eastern mountains. Marcella's *Cyclobothra* (Fig. 7; *C. marcellae*) grows up between shrubs in some of the states of Mexico's northeast, from San Luis Potosi to Nuevo Leon and Tamaulipas. In the northern part of its range is an area of lower mountains that do not capture as much precipitation. Marcella's *Cyclobothra* seeks out what moisture there is in the area by growing in relatively wet areas such as the banks of washes, mountain meadows and even conifer woods. To the south it gets progressively wetter and the species is to be found on the lower slopes of the mountains. It is difficult to describe a plant with such complex coloration, but it is often reddish-brown on the exterior and yellow on the inside. Usually the exterior of the petals and sepals are slightly different shades. The inside of the petals are covered with short yellow hairs. The flower is inverted, or nodding.

On the windward side of the eastern mountains, the Sierra Madre Oriental, tropical storms provide lush growing conditions for plants. Ghiesbreght's *Cyclobothra* (Fig. 5; *C. ghiesbreghtii*) grows at middle elevations on the windward slopes. In this habitat, it must compete against aggressive plants nurtured by the copious rainfall. The plant has adapted by becoming shade tolerant, which many species shun. Ghiesbreght's *Cyclobothra* is usually found on the north side or north slopes of the mountains and is almost always under shrubs or in the shade of trees. Its lovely flower looks surprisingly like a cat's ear. It is white to pinkish with hairs covering the petals and a distinctive horseshoe-shaped band on the lower part of the petals. This band is usually red or occasionally yellow. The plant gets tall, perhaps seeking the scant light that makes it through the subtropical canopy. The climate lies on the border between tropical and subtropical. At the medium altitudes in which the species is commonly found, winters are cooler than along the Coastal lowlands. The range of the plant is from Queretaro State south to Guatemala.

There are two other Mexican species that grow in the transition zone between subtropical and tropical in the western part of Central or Southern Mexico. Here the moisture-laden winds blow in from the Pacific, rather than the Caribbean, although the country is narrow at this point and rain

may occasionally come from the east. One species is a reddish counterpart to Ghiesbreght's *Cyclobothra*, and occupies a similar niche in the west. Pringle's *Cyclobothra* (Fig. 3; *C. pringlei*) has also adapted to intense competition by seeking out the shady areas under pines, and has learned to survive in marginal, extremely poor soils. Pringle's *Cyclobothra* is a woodland dweller at the medium altitudes of the wet, southwestward facing slopes of the Sierra Madre Occidental. This species ranges from the states of Morelos and Mexico in the north to Guerrero. It looks like a tall red cat's ear with red or occasional yellow hairs. From the side it resembles a ruby chalice.

Hartweg's *Cyclobothra* (Fig. 9; *C. hartwegi*) grows not at the border between the subtropical and tropical, but, rather, in both areas. At the north end of its range, in Zacatecas, winters are cool. To the west, in Nayarit, the winters (actually a dry season) are balmy. The species has adapted to both areas, although it tends to grow in shade in the tropics, where the heat of summer can be intense, but full sun to the east and north. The plant grows on both the windward and the leeward side of the mountains, adapting to the different rain patterns by growing in different terrain. In the drier areas, the plant grows in meadows where it can capture more rainfall. Nearer the coast the plant grows on slopes, where the water from the torrential monsoons drains off. Hartweg's *Cyclobothra* has a large, showy, nodding flower of purple with green sepals and a yellow interior. This is a species of west-central Mexico from Jalisco to Zacatecas, and from Aguascalientes west to Nayarit.

The most common species in Mexico is the Bearded *Cyclobothra* (Fig. 6; *Calochortus barbatus*), which has the largest range of any Mexican species. It grows in the foothills and up to medium altitudes on the leeward slopes of the mountains surrounding the Mexican Plateau, generally in full sun. It can be found from Chihuahua in the north to Oaxaca in the south, from Durango east to Hidalgo. This vast area varies in rainfall totals, soils and climate, but the plant is to be found in areas of roughly similar altitude. The species receives considerably more rainfall in the south of its range than in the north, almost twice as much. It has adapted to some degree by growing on wetter terrain in the north, although this does not compensate entirely. The range of the plant lies almost entirely in the subtropical zone, although it borders on the temperate at its northwestern end, in Chihuahua and Durango. In this latter region, a variety of the Bearded *Cyclobothra* is generally found which is smaller than the parent plant, with brown on the outside of the upper part of both the petals and sepals. To the south and south-

west, the flower is frequently all yellow, with brownish hairs covering the petals. It is also a nodding species, with serrated petal edges, much like an inverted Weed's *Cyclobothra*. The spread of the petals has suggested the name by which the plant is known in the area surrounding Mexico City: "*ayatito*," meaning a skirt large enough to hide things under (according to Prof. Madrigal-Sanchez, a Michoacan botanist).

Central Mexico has a band of mountains that run across the interior, enclosing the Plateau country on the south and connecting the two main north-south ranges to the east and west. The area captures rainfall from both the Caribbean and the Pacific. This area is active both seismically and volcanically with frequent, intense earthquakes and, less commonly, volcanic eruptions. The disruptions in the surface layers caused by the geologically active faults in the region contribute to a dynamic in the plant populations of the area. After an earthquake or an eruption, new soils are created or upthrust. Not all species will grow on new ground, which is frequently low in plant nutrients. However, such areas afford reduced competition from other plants due to their lack of such nutrients. Botanists and naturalists refer to plants that are often found on such newly created soils as "pioneers." Many *Calochortus* species are pioneer plants as they tolerate soils of low fertility and favor the reduced competition on new soils. Some of these are found in this geologically active band of central mountains across the center of the country.

One such species is the Purple *Cyclobothra* (Fig. 10; *C. purpureus*), which inhabits open meadows or grassy slopes at medium altitudes. The species grows in sun from Durango southeast to northern Oaxaca in the central mountains. In appearance it is not unlike a small Hartweg's *Cyclobothra*, with nodding, open flowers varying from a deep and intense purple to brown. Occasionally the sepals of the plant are green or another contrasting color. The petals are generally yellow. The nodding habit of the flower has suggested a dangling earring hanging below an ear by a thin wire, and the plant is known locally as "*aretillo*" (earring).

An even smaller flower of similar appearance can be found on the southwest facing slopes of the trans-Mexican mountains. In northern Morelos, the foothills of the mountains have an unusual shape. They look like door-knobs set into the ground. These "knobs" of the Sierra de Tepoxtlán often have small tops that support plant life. The shallow soils are isolated from the surrounding area and unusual species can sometimes be found. Among

these is the Morelos *Cyclobothra* (*C. cernuus*), which grows in small mulch pockets between the rocks or even in clefts on the sides of the knobs. It looks like a smaller version of the Purple *Cyclobothra* with a purple exterior and a yellow interior. A local species, it is confined to northern Morelos. In the village at the foot of the knobs where we were hunting for this species, Nahuatl, the language of the Aztecs, is still spoken. A resident of the village told us that the name of the flower in Nahuatl is "*tlotlocotl*." Further west in the uplands of the Trans-Mexican mountain chain are two woodland species. One closely resembles the Morelos *Cyclobothra*. Like many Mexican *Calochortus*, it grows in the shade of pine forests on slight slopes, and ranges from Michoacan east to Mexico State and south to Oaxaca. This species (*C. spatulatus*) is called "*campanita*" ("little bell") by the locals, as the nodding purplish-brown flowers suggest a bell. Unlike the larger Purple *Cyclobothra*, this species has numerous hairs on the interior petals. "Little Bells" produces small bulbils at the base of the leaves in great profusion.

Another species has upright flowers of intense red. Hinton's *Cyclobothra* (Fig. 4; *C. fuscus*) can be found in conifer-oak woodlands at medium altitudes, but also in open, areas with poor soils at lower altitudes, where it is a pioneer species. Hinton's *Cyclobothra* grows in roughly the same range as "Little Bells," but further west, from Jalisco east to Mexico State in the western end of the Trans-Mexican Mountains.

Finally, there is one truly tropical species. In the lowlands of the south the climate is always warm, year round. In the summer it is humid, hot and intensely rainy. Only one *Cyclobothra* species is known to have adopted itself to such conditions. *Calochortus balsensis* has just recently been named and described in the botanical journals by a Mexican botanist, Dr. A. Garcia-Mendoza (1991). The flower of this species is large, nodding and globe-shaped, with hairs on the inside of the petals. It is a very showy yellow with green on the outside of the sepals on some plants. The local name for the plant is *coconchi*, suggesting an affinity to the conch shells found at the seaside. The plant is found on small hills and slopes growing among grasses or in the light shade of shrubs and trees. This habitat can get extremely wet, with over fifty inches of rain per year. The plant's range is on the southwest coastal hills from Guerrero to Oaxaca. It blooms late in the season, in October, perhaps needing a long growing season to develop such a large, spectacular flower.

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EUCOMIS—AN ELITE ÉCLAT OF EXCELLENCE

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See page 84–85 for color plates.

INTRODUCTION

Eucomis, a beautiful and fascinating feature of South African rocky grasslands, sadly receives little attention for its allure as a garden ornamental. It is familiar to most people as the 'pineapple lily'; a name that alludes to its brilliant array of small flowers topped with an aggregation of leafy bracts (the coma); an appearance likened to the pineapple (Fig. 1). *Eucomis* is derived from the Greek word '*Eukomes*' which translates to 'Good headed', in reference to the coma. The prominent coma in *Eucomis* clearly differentiates this genus from other members in the family Hyacinthaceae.

This small genus of 11 species is endemic to southern and tropical Africa with a concentration of 10 species in South Africa. The only non-South African species, *E. zambesiaca*, is restricted to the highlands of Malawi. In South Africa, *Eucomis* is a much sort-after medicinal plant. The bulbs are used in African traditional medicine to treat a variety of ailments that include stomach complaints, pregnancy discomforts, urinary infections and blood disorders.

TAXONOMIC HISTORY

The first phrase descriptions of *Eucomis* were prepared by Dillenius in 1732. Linnaeus (1753) described *Eucomis regia* as *Fritillaria regia* in *Species Plantarum*. *Fritillaria* is a European genus of 100 species, in the family Liliaceae. In 1788, the French botanist, Charles L Heritier de Brutelle, established the genus *Eucomis*, recognizing the species, *E. regia*, *E. nana* and *E. punctata*. Baker (1897) presented a major taxonomic revision of the group in *Flora Capensis* in which he recognized 9 species. Almost 80 years later William Frederick Reyneke (1972) provided a treatment of *Eucomis*, retaining Baker's species. He established subspecies within *E. autumnalis* and *E. regia*, and varieties within *E. comosa* to accommodate the great degree of variation within these species. In 1976 he described a further species, *E.*

schijffii, in honour of Prof. Hermanus Philippus (Manie) van der Schijff, who contributed to the fields of plant geography, ecology and morphology of South African plants (Reyneke, 1976).

DESCRIPTION

Perennial, bulbous herbs. Bulbs pear to dome shaped, with or without a tunic of old brown scale leaves. Leaves deciduous, lanceolate-linear to spatulate, with or without purple spots or striations on the adaxial and/or abaxial surface, erect or prostrate, with undulate or slightly crisp margins. Peduncle cylindrical or clavate, prostrate or erect, 3.5 to 120 cm long, green, with or without varying degrees of purple specks. Coma bracts may or may not overhang the inflorescence, green, with or without purple variegation. Inflorescence a sparse to dense raceme or, more rarely, a pseudospike; number of flowers variable. Flowers 6-merous, scented, varying from fragrant (coconut-like) to offensive, actinomorphic; perianth-segments white, yellow-green or maroon, or a combination of these colors, persistent. Stamens six; filaments deltoid, partially free, each one fused to the base of the perianth-segments and to each other basally to form a cup-like structure that is often laden with nectar; anthers versatile with introrse dehiscence; pollen yellow, powdery. Style about equal to height of filaments. Ovary round, trilobular, green, sometimes with purple coloration. Seeds round, black, 2.5 mm in diameter.

SPECIES DIVERSITY

Species within *Eucomis* can be separated on plant size, and leaf and flower coloration. The “Goliath” of the group is the colossal *E. pole-evansii* (Fig. 2), with leaves up to 1.2 m long and a flower stalk of 1.8 m in its preferred wetland habitats. Its tall, majestic appearance has earned it the name “Queen” of the genus. The “David” of the group, *E. schijffii* (Fig. 3) grows to about 35 cm tall and displays brilliantly uniform reddish-purple flowers on a stunted flower stalk (ca. 25 cm tall) that emerges from a rosette of maroon-tinged leaves. This impressive species is perched on precarious cliff faces and mountain summits of Sentinel Peak, a captivating component of the Drakensberg mountains.

Eucomis comosa, like *E. pole-evansii*, is a tall plant that prefers cool spots along river and stream banks. It differs from the latter in that its leaves and peduncles are recumbent. Like *E. montana* (Fig. 4), its leaf bases are ornamented with purple striations. *E. autumnalis* (Fig. 1) is similar in appearance to these species. Small plant stature and reddish-purple leaf and flower

variegation in *E. bicolor* (Fig. 5), *E. vandermervei*, and *E. humilis* (Fig. 6) clearly distinguish them from the larger green and white flower forms of *E. pole-evansii*, *E. comosa* and *E. autumnalis*.

POLLINATION

Eucomis flowers fit typically into pollination syndromes associated with ants, solitary bees, flies, beetles and wasps, and indeed the flowers do play host to these insects. Visitors (Fig. 7) have been observed feasting on nectar, pollen and floral tissues. Nectaries, situated in grooves on the apical region of the ovary, produce copious amounts of sweet aqueous nectar that collects in the 'cup' at the base of the fused stamens. Insects congregate at the nectaries and the 'cup' to siphon rewards for their services. Ants tend to enter the flower in between the perianth-segments and while feeding at the 'cup', direct their abdomens towards the anthers, thus at times becoming dusted with pollen. In those instances where ants feed at the nectaries, they perch on the style and rub their abdomens against the stigmatic surface, thereby transferring pollen. Although solitary bees have been observed collecting pollen, they do not seem to actively pollinate the flowers. Pollination effected by flies and beetles is probably coincidental; flies have been observed feeding on nectar that dribbles down onto the perianth-segments, while beetles are more destructive, feeding on the floral tissues, especially the perianth-segments and ovaries. In contrast, ants and wasps are more dedicated to pollination. Wasps alight on the perianth-segments and forage actively on the open flower, and, in the process, are showered with pollen grains.

ECOLOGY

Eucomis species occur over a wide range of habitats from coastal grasslands to alpine vegetation of the Drakensberg mountains, from well-drained soil to marsh wetlands, and from full sun to partial shade in riverine shrub vegetation. With the exception of the winter rainfall *E. regia*, all *Eucomis* species occur in the summer rainfall region of southern Africa. *E. regia* subsp. *regia* (Fig. 8) is restricted to the fynbos biome of the Western Cape Province and *E. regia* subsp. *pillansii* to the succulent karroo biome of the Western and Northern Cape Provinces. The summer rainfall *Eucomis* species reside mostly in undisturbed rocky grasslands that are exposed to burning. *E. autumnalis* is the most versatile species; it inhabits warm coastal grasslands as well as the cool, frosty mountains of the Drakensberg. *E. schijffii* on the other hand, is restricted to alpine vegetation in the Drakensberg. Most taxa prefer well-

drained soils, with the exception of *E. comosa* and *E. pole-evansii*. The latter species grows in knee-deep wetland marshes. The shade tolerant, stream bank dweller *E. comosa*, like *E. pole-evansii*, does well in permanently damp conditions and they are both suitable for moist, dappled shady spots in the garden.

On Sentinel Peak, baboons remove flower stalks of *E. autumnalis* in a possible attempt to feed on the nectar. *E. regia* subsp. *regia* is subject to bulb destruction by burrowing rodents that feed on the bulbs.

CULTIVATION

Eucomis montana, *E. pole-evansii*; *E. autumnalis* subsp. *clavata* and *E. comosa* var. *comosa* were found to reproduce asexually quite readily by forming bulblets at the basal plate. Craib and Brown (1998) reported a similar pattern within populations of *E. vandermerwei*, and suggest that this is an adaptive strategy for plants to survive damage from rodents and trampling hooves of game and livestock. Masses of seedlings were noted in healthy populations of *E. autumnalis*, but this was not noticed in populations of other species. Propagation of plants through seeds appears to be straightforward. Seeds of *E. autumnalis* and *E. schijffii* germinate fairly easily. According to Doult (1994), dried seeds of *E. schijffii* require about 35 days to germinate.

ECONOMIC IMPORTANCE

Eucomis is an attractive garden ornamental. The maroon-tinged species offer a splendid color supplement in gardens and the “Queen” of the genus is ideal for water features. The true effect of *Eucomis* as a garden ornamental is appreciated when plants are grown in mass. Since the flowering heads of *Eucomis* last up to 2 weeks, they would be suitable as cut flowers. *E. schijffii* is suited to cold Berg conditions, can tolerate moderate frost, and would therefore be ideal for European gardens.

Regrettably, the full horticultural potential of the group has not yet been exploited. At the moment, *E. autumnalis* is the only species sold at nurseries in South Africa, though nursery managers have indicated a keen interest to market other color forms of *Eucomis*. It is clear that the genus offers potential to the horticultural industry to launch select species into the trade.

CULTURAL USES

Traditional medicines are an integral component of African culture. *Eucomis* is one of the many herbs used extensively in preparation of herbal medicines by the Zulu, Tswana, Xhosa, Pedi and Sotho people of South

Africa. In the South African muthi markets, species of *Eucomis* trade under various Zulu names: *umakhandakantsele* and *ukhokho* for *E. autumnalis* subsp. *autumnalis*; *umathunga* for *E. autumnalis* subsp. *clavata*; *ubuhlungu-becanti* for var. *comosa* and *imbola* for *E. bicolor* (Hutchings et al., 1996).

Bulbs of *E. autumnalis* subsp. *clavata* are used in decoctions to treat fevers, coughs, biliousness, lumbago, syphilis and blood disorders (Watt and Breyer-Brandwijk, 1962). The Zulu people use *Eucomis* bulbs to treat urinary infections and to facilitate childbirth. Byrant (1966) relates a Zulu belief around urogenital disorders. A male who becomes afflicted with a urogenital disorder is inevitably considered to have had an affair with a married woman. The affliction is due to a charm prepared from charred and pulverised animal parts in the possession of the cuckolded husband. The magic charm is regarded as the *izembe* (axe) or *umsizi* (helper) of the husband and it targets the kidneys and genital organs of his challenger. A dosage of *E. autumnalis* subsp. *autumnalis* and the bark of *Eucalyptus* sp. (*umpisikayihlangulwa*) is used to reverse the 'curse'. The treatment results in profuse perspiration, followed by vomiting, ultimately purging the body of the impurity.

In contrast to the use of *Eucomis* in childbirth by the Zulus, the Sotho people consume a herbal concoction to prevent premature labour (Watt and Breyer-Brandwijk, 1962). The Xhosas apply a decoction containing *Eucomis* bulbs to the gums of babies with teething problems (Watt and Breyer-Brandwijk, 1962). The Sotho and Tswana people also use *Eucomis* as an antidote for hangovers on nights of their festivities (Watt and Breyer-Brandwijk, 1962). The Tswana heal colic, flatulence and abdominal distension with a decoction of bulb shavings and roots of *Eucomis* served in milk or water or with meat (Watt and Breyer-Brandwijk, 1962). Pooley (1998) records that *E. comosa* is used to treat rheumatism in traditional medicine.

Eucomis autumnalis subsp. *autumnalis* is recorded as being highly poisonous. Gerstner (1941) and Watt and Breyer-Brandwijk (1962) reported on an incident where a young woman suffered severe hemorrhaging due to poisoning from *Eucomis*. They consider this due to the saponins in the plant, which act as a strong haemolytic.

CONSERVATION STATUS

Socio-economic factors coupled with traditional beliefs promote dependence on traditional remedies by South Africa's rural communities. The trade in medicinal plants comprises the informal *muthi* traders and the formal herbalists. The strenuous task of collecting plants often involves walking several kilometers over rugged terrain. This, in conjunction with shrinking

habitats, has led to the indiscriminate harvesting of bulbs that has subsequently placed a huge strain on natural plant populations. Due to the various applications of *Eucomis* within the realm of traditional medicines, it has become a much-targeted herbal plant. Surveys conducted at *muthi* markets confirmed that *Eucomis* is largely exploited for its medicinal properties and that the genus is in short supply (Cunningham, 1988). Bulbs sold at these markets are priced according to size and season; during the winter months, bulb collection comes to a virtual halt as the plants die back. Bulbs are therefore more expensive during this period.

Another aspect that impacts directly on the survival of *Eucomis* populations is the conversion of natural habitats to large-scale exotic forests. Visits to some previously recorded grassland sites for *Eucomis* have been disappointing, as these areas are now under commercial tree plantations. Anthropogenic impacts have placed species like *E. autumnalis* subsp. *clavata*, *E. vandermervei*, *E. humilis*, *E. montana* and *E. schiffii* under threat as noted by Scott-Shaw (1999), Walter and Gillett (1997) and Taylor (1996).

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***EUCOMIS*—A HORTICULTURAL REVIEW OF THE GENUS**

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See page 85 for color plates.

INTRODUCTION

Eucomis species and hybrids are primarily used outdoors in borders, beds, and rock gardens where the flowering period can be as long as eight weeks long (Bryan, 1989; Genders, 1973). Although this genus has not been extensively used as forced plants, it has potential not only as a flowering potted plant (Fig. 1) but also as a fresh cut flower. Common names for *Eucomis* are: "Ananas Plant", "King's Flower", "Pineapple Flower" (*E. bicolor* Bak.), and "Pineapple Lily" [*E. autumnalis* ssp. *autumnalis* (Miller) Chitt.] (De Hertogh and Le Nard, 1993).

GENERAL ASPECTS

Botanical Classification, Distribution, and Description

Eucomis is now classified in the Hyacinthaceae (Du Plessis and Duncan, 1989; Speta, 1998). The name, *Eucomis*, is derived from the Greek word "eukomos", meaning beautiful haired (Bryan, 1989) or lovely haired (Bryan and Griffiths, 1995). The genus contains at least 11 species and they are indigenous to tropical and southern Africa (Bryan and Griffiths, 1995; Du Plessis and Duncan, 1989; Van Scheepen, 1991). Some of the species and their origins are: *E. autumnalis* (Miller) Chitt. ssp. *amaryllidifolia* (Baker) Reyneke and *E. autumnalis* (Miller) Chitt. ssp. *autumnalis*, Eastern Cape Province, Natal, and northward to Zimbabwe; *E. bicolor* Baker, the Natal, Lesotho, and Orange Free State; *E. comosa* (Houtt.) Wehrh., the Eastern Cape Province and Natal; *E. pole-evansii* (N.E. Br.), the Natal and Swaziland; *E. regia* L' Her., Western and South-Western Cape Province; *E. zambesiaca* (H.G. Reichb.), Malawi; and *E. autumnalis* (Miller) Chitt. ssp. *clavata*, the Eastern region of South Africa and Botswana.

De Lange (personal communication) has indicated that *Eucomis* species are used by African tribes for several purposes. The Southern Sotho use the bulb as a colic remedy, while the Xhosa boil the bulbs along with other ingredients and use it for rheumatism. The Zulu consume it for coughs and

urinary diseases. In contrast, the Tswana mix the bulb with animal fat and smear it over the body, believing that this provides protection against the evils of witchcraft. Although used for these purposes, the bulb is highly poisonous and therefore must be used with care. Also, due to bulb collecting, some *Eucomis* species are becoming endangered.

Eucomis have a tunicated bulb that is ovoid or globose in shape (De Hertogh and Le Nard, 1993). They produce strap-like to lanceolate leaves arranged in basal rosettes (Figs. 1, 2). There is variation in the coloration and striping of the foliage (Figs. 2, 3). Depending on the species or cultivar, the flowers are whitish, greenish, or pale pink (Du Plessis and Duncan, 1989). They are arranged in a terminal bracted raceme on a scape that can be 1 to 5 ft (30 cm to 1.5 m) tall. The raceme is crowned with a cluster of sterile leafy bracts. The florets of some species are sweetly fragrant, which is an excellent characteristic. However, some have an unpleasant odor. Each floret has six 1-nerved perianth segments that are united basally into a cup with six stamens (Liberty Hyde Bailey Hortorium, 1976). The anthers are versatile affixed to the filaments, which are dilated and united basally. The fruit is a 3-valved, terminally loculicidal capsule. The chromosome numbers for *Eucomis* are $2n = 15$ and 16 (Darlington and Wylie, 1955).

The root system is branched and has contractile roots (Reyneke and Van Der Schijff, 1974). Their mechanism of root contraction is very similar to other geophytic monocots. Contraction produces tangential and radial broadening and longitudinal shortening of the contractile parenchyma. Kawa and De Hertogh (1991) reported that seedlings have branched and contractile roots and observed the presence of root hairs. Bulbs (22/23 cm, in circumference) had an average of 85 basal roots per bulb.

World Production Areas, Cultivars, and Export Statistics

The Netherlands and South Africa are the only countries reporting that they commercially produce bulbs. In 1988, The Netherlands had 5 acres (2 hectares) of bulbs (Produktnota Bijgoed, 1988). No acreage is available for South Africa. *Eucomis* is on the USDA/APHIS preclearance list and can be easily transported to the United States. They should be shipped under ventilated conditions at 48° F (9° C) (Van Leeuwen and Van den Weijden, 1995).

The cultivars and/or species that are commercially available have been described by Van Scheepen, 1991. They are: (1) *E. bicolor* (flowers green bordered, reddish lilac; leaves undulated), (2) *E. bicolor* 'Alba' (flowers greenish white; leaves and stems not spotted), (3) *E. comosa* (flowers greenish white with purple pistil; leaves spotted with crimson), and (4) *E. pole-evan-*

sii (flowers green). Bulb sizes exported from The Netherlands are: 12/14, 14/16, and 16/up cm in circumference. Bulbs as large as 26/30 cm, in circumference, are available from South Africa.

Multiplication Systems

Commercially, bulbs are produced by either offsets or seed (Langeslag, 1989). The offsets grow and develop slowly. When stocks are increased by seed, they are sown in the spring. Most seedlings take 4 to 5 years to flower. However, only three years are required for *E. zambesiaca* if the bulbs are healthy and vigorous (Du Plessis and Duncan, 1989).

Tissue culture techniques have been reported for *E. autumnalis*, *E. bicolor*, and *E. pole-evansii* (De Lange et al., 1989). Sterilized bulb scales, leaf bases, or flower stalks were grown in a balanced medium and shoot proliferation was stimulated by plant growth regulators. Small plants were successfully transferred to a rooting medium and prepared for soil propagation. Ault (1995) reported that *E. autumnalis*, *E. comosa* and *E. zambesiaca* could be propagated *in vitro* by twin-scale explants. Shoot proliferation and rooted plants were obtained from single shoot explants. Hybrids have been produced by embryo rescue techniques (F. Meyer, personal communication). These techniques allow the hybridization of species as well as the production of disease-free plants. They are commonly used in the production of hybrid offspring of *Gladiolus* (Ziv and Lilien-Kipnis, 1990) and *Lilium* (Van Aartrijk et al., 1990).

Breeding Goals

De Hertogh (1990) listed several criteria for the selection of bulbous and tuberous plants for garden and forcing use in the U.S and Canada. The ten major ones are: (1) For production purposes, the bulbs must multiply readily under a wide variety of soil and climatic conditions and they must be profitable to produce. (2) The bulbs must be adaptable to and tolerant of mechanical handling systems, e.g., harvesting and grading. (3) Outdoors, the bulbs must be tolerant of a wide range of soil types, drainage situations, and air pollution levels. (4) The bulbs must require the use of few, and preferably no, insecticides or fungicides. This is true not only for bulb growers, but also for home gardeners and landscapers. Thus, there must be resistance or tolerance to all major diseases and insects. (5) The bulbs must have the ability to withstand extended periods of drought conditions either during the fall or spring for spring-flowering bulbs or during the summer for summer flowering bulbs. In addition, they should not be high water-requir-

ing cultivars or species. (6) For homeowners and certain landscape uses, the bulbs must have a high capacity to perenniate in the garden. (7) There must be a range of bulbs available for full sun, partial shade, and full shade locations in the garden. (8) The bulbs must have low fertilizer requirements. (9) As many of the bulbs as possible should be adaptable to outdoor container growing for use on patios and balconies. (10) All bulb species should provide as wide a range of flower colors and types that is genetically possible.

GROWTH AND DEVELOPMENT AND FLOWERING

Under indigenous conditions, most *Eucomis* species are deciduous geophytes (Du Plessis and Duncan, 1989). They are summer-growing and dormant in winter. An exception is *E. regia*, which is winter-growing and senesces in the summer. The time of flower initiation has not been reported, however, in the production fields and gardens flowering occurs in August to September in the Northern Hemisphere (Langeslag, 1989).

In North America, the overall USDA Climatic Zone (Cathey, 1990) usage is as follows. In Climatic Zones 4 to 6, they can be grown outdoors in containers, but must be stored indoors during the winter months. In Climatic Zones 7 and 8, bulbs may be left in the ground during winter, but they must be covered with a mulch. They are hardy in Climatic Zone 9 and need no winter protection.

The bulbs require full sun to partial shade (Genders, 1973). Bulbs should be planted five inches (12.5 cm) deep and 12 to 24 inches (30 to 60 cm) apart, except for *E. pole-evansii*, which requires a wider spacing.

BULB PRODUCTION

General Aspects

Langeslag (1989) has provided the only bulb production information available. Under Dutch conditions, bulbs are harvested in November and quickly dried at 68° F (20° C). They are graded and those less than 12 cm, in circumference, are used for planting stock while the larger bulbs are marketed. After grading, the planting stock is stored under well ventilated conditions at 63° to 68° F (17° to 20° C) until planted in mid-March to mid-April. About 70,000 to 100,000 bulbs (8/10 cm, in circumference) are planted per hectare. They are planted 3 to 4 inches (7.5 to 10 cm) deep. Seeds are planted at a rate of 75 ml per square meter and covered with 1/4 to 3/4 inches (1 to 2 cm) of soil.

Agronomic Requirements

Eucomis prefer a well drained soil that is high in organic matter with pH levels of 6 to 7 (Langeslag 1989). They require a moderate to high fertilizer program. The optimal summer growing temperatures are 70° to 90° F (20° to 32° C). The bulbs require moist conditions in the spring and summer, but prefer dry conditions in the fall and winter. No serious pests or diseases have been reported for the genus.

Postharvest Bulb Storage and Transportation Requirements

Postharvest storage requirements for flowering bulbs have been studied by Van Leeuwen and Van den Weijden (1995). They found that bulbs must be stored dry and under well ventilated conditions at 48° F (9° C). While no specific transport requirements have been reported, the above conditions are used.

Production Economics

Under most conditions, *Eucomis* require at least three years to produce flowering sized bulbs. While production economics have not been reported, one of the systems reported by De Vroomen (1993) should be applicable.

Bulb Forcing

When forced at 60° to 63° F (16° to 17° C) night temperatures, we have found some selections to be marketable in 70 days. Although this is within the acceptable commercial forcing range for many greenhouse crops, it is advised that the plants be marketed when the floral buds are visible in the foliage (Fig. 2). This reduces the number of greenhouse days required and it maximizes the "Consumer Life" of the flowering potted plant. In USDA climatic zones where it is hardy, the forced bulbs can subsequently be planted in the garden in late spring.

CONCLUSIONS

The variation in coloration, shape, and size of the foliage in *Eucomis* (Figs. 1, 2 and 3) provides a striking plant appearance. Thus, even when not in flower, *Eucomis* can be an attractive house or garden plant. While used primarily in gardens, it has the potential to become a valuable potted plant. It is clear, however, that additional research is needed. Although it can be used as a cut flower (Langeslag, 1989), a major problem is the long greenhouse time required to bring the plants to this stage of development.

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PROPAGATION OF SPECIALTY BULBS

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INTRODUCTION

Bulbous plants can be propagated by seed, by natural vegetative reproduction (offsets or division), but also through "artificial" propagation methods. The most well-known of these latter are partitioning, scaling and scoring. A number of major bulbous crops such as lilies, hyacinths and narcissi are mass reproduced in this way. The techniques are especially useful for those plants that do not reproduce easily or at all by natural reproduction methods but for which a large number of offspring is required in a short time.

In this article the emphasis is on the artificial methods of propagation for tender, specialty bulbous plants, both summer- and winter-growing. These experiments were conducted in the Netherlands from November 1997 to June 2000.

PROPAGATING BULBS BY PARTITIONING, SCALING AND DOUBLE-SCALING

Various protocols are described in the literature for the propagation of bulbs through partitioning, scaling and double-scaling. With partitioning the bulb is cut from nose to bottom into several parts with a part of the basal plate attached to each section. The main bud is destroyed this way. The axillary buds will grow into new bulbs. Adventitious bulbs will also develop. The amount of parts depends on the size of the used bulb: about four with a *Lachenalia* species up to 12 or 15 with a fully grown *Veltheimia* or *Eucomis* bulb. The principle of scaling is that rings or scales are taken of the bulb and of the basal plate. Sometimes the scales or rings are cut into smaller sections. Where the rings or scales were attached to the basal plate, new adventitious bulbs will grow. Double scaling is a combination of partitioning and scaling. With this technique two or more scales or parts of rings are taken of the bulb. These parts are left on the basal plate. These protocols, however, are not directly applicable to the specialty bulbs with which the author has experimented. This is mainly due to the fact that the protocols described have been developed for bulbous plants that are grown outdoors in The Netherlands while the author's interests lie with bulbs that are grown indoors and require warmth. In this respect, the article by Van Leeuwen and Van der Weijden (1997) is the most helpful.

Mori et al. (1997) investigated which circumstances are best for *Nerine sariensis* when using scoring as the means of propagation. Either at the end of May or the end of October, six incision are made in the bottom half of the bulbs. The bulbs are kept dry for two weeks at a temperature of 20 or 25°C. The bulbs are subsequently potted up for 6 months in a medium containing cabbage and rice chaff.

Van Leeuwen and Van der Weijden (1997) have investigated the possibility of partitioning *Chionodoxa*, *Eucomis*, *Galanthus*, *Muscari*, *Scilla* and *Veltheimia*. For *Eucomis bicolor*, *Eucomis comosa* and *Veltheimia bracteata* research was conducted to see whether differences occurred when the bulbs were either kept for 12 weeks in vermiculite and then planted up in potting compost or were planted up directly after propagation. The same starting points were used. Part of the experiment was an investigation of the effects of temperature variation. For *E. bicolor* no differences were observed between the two methods as regards the number of newly formed bulbs, nor did temperature have an effect on the number of bulbs. The best results with *E. comosa* were obtained by keeping them for 12 weeks in vermiculite at 17, 20 or 23° C and then potting them up. *V. bracteata* formed most bulbs when potted up directly and kept in vermiculite for 12 weeks at a temperature of 23° C.

Bircher et al. (1998) concluded that the best protocol for *Bowiea volubilis* was to take the outer scales from the bulb and keep them in a cool place for two weeks, then plant the scales in coarse river sand. After six months, the newly formed bulbs can be taken off the scales.

The following protocol has been tried with a number of unusual bulbs, both summer- and winter-growing. The winter-growers involved were *Albuca* sp., *Drimia haworthioides*, *Haemanthus albiflos*, *Haemanthus coccineus*, *Lachenalia mathewsii*, *Lachenalia unicolor* and *Veltheimia capensis*. The summer-growers used were: *Bowiea volubilis*, *Drimiopsis maculata*, *Eucomis bicolor* and *Galtonia candicans*.

Protocol. Experiments were begun 13 or 17 weeks before the start of the growing season. Sufficient moist vermiculite (3:1 vermiculite : water by volume) was allowed to stand for about 24 hours, then placed in a polythene bag with several air holes in the upper part of the bag. The bulbs were divided, and the parts placed in the vermiculite (either mixing parts and vermiculite or the parts planted with their bottom half in the vermiculite) at a ratio of 50% vermiculite and 50% bulbs (Fig. 1). The bag was closed and placed in a dark space at a temperature of 17-20°C. The bags were checked regularly to determine whether the vermiculite was still moist and water was

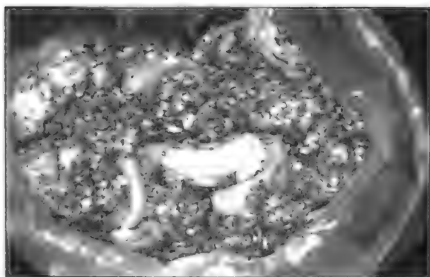


Fig. 1. Parts of *Galtonia candicans* in vermiculite, with the newly formed bulbs already visible



Fig. 2. Parts of *Albuca* sp., five weeks after propagation

added when necessary. After 13 or 17 weeks, the parts were removed from the vermiculite and planted in potting compost (commercial potting compost mixed with sand at a volume ratio of 3:1. The bulbs were placed in a light spot, but not in direct sunlight, and the soil kept moist, but not wet. The number of bulbs formed at the end of the growing season (both deciduous and evergreen types), as well as the size of the bulbs was recorded.

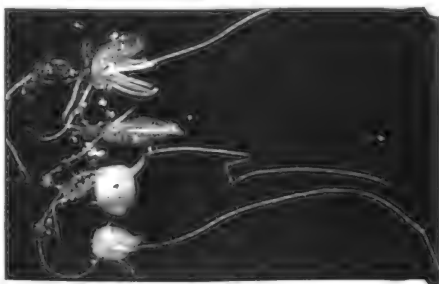


Fig. 3. Parts of *Albuca* sp., 13 weeks after propagation

Results. A few remarks have to be made regarding these results. Firstly, the experiment was mainly aimed at developing a protocol (does it work?) and only to a lesser extent at reaching an optimal result as far as number and size of the bulbs produced was concerned. Also, almost all tests were performed only once.

The first adventitious bulbs in *Albuca* sp. *Galtonia candicans*, *Lachenalia mathewsii* and *L. unicolor* were already visible four weeks after propagation, some of which had already formed roots. The newly formed bulbs did not go dormant, but formed roots and leaves (Fig. 2 and 3). These sprouting bulbs were kept in the vermiculite until 13 weeks after propagation and were then planted. Some of the bulbs rotted away or died.

The parts of *Bowiea volubilis*, *Drimia haworthioides*, *Veltheimia capensis* and *Crinum x powellii* were treated according to the protocol described above. The parts of the first three species rotted off during the period in the vermiculite due to the vermiculite being too wet. A number of the parts of *Crinum*

x powellii rotted. Two parts were potted up and both formed a new bulb. During the growing season, these parts dried up as well as the newly formed bulbs.

In *Haemanthus albiflos* the techniques of scaling, double scaling and partitioning were tried in the experiment. With scaling, the parts of the bulbs remained intact till up to a year after planting, but no adventitious bulbs were formed. This was also the case with double-scaling and partitioning. At the time of planting, no newly formed bulbs were visible. The bulbs grew very slowly in the beginning, up to a year, after which they grew faster.

Scales of *Haemanthus coccineus* were cut into two parts on August 22nd, 1998 and then submitted to the protocol described above. Only in December 1999, were two small adventitious bulbs visible on two separate scales (Fig. 4). The parts of the bulbs remained intact during the entire period, except for a slight drying on the upper end. Another bulb of *H. coccineus* was cut into 4 parts during the dormant period. The parts were planted directly into potting compost. Within one growing season, two new bulbs had formed (Fig. 5).

Eucomis bicolor was subjected to scaling, double-scaling and partitioning. Scaling and double-scaling did not result in new bulbs. The parts dried or rotted after a year. Only with partitioning were new bulbs formed (Fig. 6). This could indicate that only buds sprout and no adventitious bulbs are formed. Some of the newly formed bulbs sprouted in the first growing season, others did not.

In the underside of a *Crinum x powellii* bulb, six incisions were made towards the nose. The bulb was kept dry at room temperature for three weeks. It was then planted in potting compost. Five months after propagation, leaves of newly formed bulbs were visible (Fig 7).

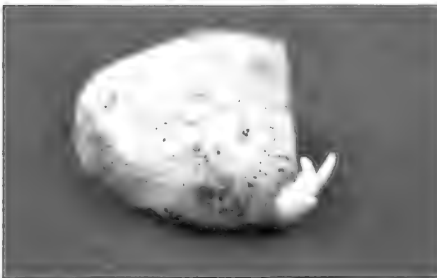


Fig. 4. Scale *Haemanthus coccineus* with adventitious bulb, 18 months after propagation



Fig. 5. Parts of bulb of *Haemanthus coccineus* with newly formed bulbs, eight months after propagation.



Fig. 7. Bulb of *Crinum x powellii* with three newly formed plants, five months after propagation



Fig. 6. Parts of bulb of *Eucomis bicolor* with newly formed bulbs, 13 weeks after propagation

PROPAGATION FROM LEAF CUTTINGS

According to the literature, bulbous plants can be propagated by means of taking leaf cuttings. It is reported that this method can be used in *Hyacinthus* (Krause, 1980), *Lachenalia* (Duncan, 1988; Suh and Lee, 1997) and *Haemanthus albiflos* (Du Plessis and Duncan, 1989).

Duncan (1988) describes how *Lachenalia* sorts can be propagated by leaf cuttings. One or more leaves are taken from healthy, virus-free plants and, depending on the size of the leaf, cut into several parts. The leaves or parts of leaves are planted in a rooting medium. Duncan mentions a medium of equal portions river sand and vermiculite. The bottom centimetre of the leaf parts are put in the medium. The whole is placed in a shady spot and the medium is kept moist. After about a month, the first bulbs and roots will have formed. From the moment the original leaf dies, the medium is kept dry. Duncan indicates that this technique can best be used with species that have large leaves.

Suh and Lee (1997) describe the results of leaf propagation experiments with *Lachenalia aloides* 'Pearsonii'. The investigation was directed at finding out how many bulbs were formed under different circumstances: which part of the leaf, potting medium, planting temperature, length of time spent in medium. Suh and Lee conclude that the best results are obtained by taking the bottom part of a leaf, by putting that in a potting medium of equal parts peat and perlite and to keep the cuttings at a temperature of 20° C.

The experiment with *Haemanthus albiflos* sought to investigate whether propagation through leaf cuttings is possible and if so, whether there are any differences in the various parts of the leaves as regards the number of bulbs formed and their size.

Protocol. At the beginning of the growing season (December), a leaf that had formed the previous year was taken from the plant. The leaf was cut just above the bulb. The leaf was cut horizontally into three parts: top, middle and bottom. The three parts were put 1 cm deep in a mixture of potting compost and sand (volume ratio 4:1), and placed in a sufficiently light spot, but not in direct sunlight. During the whole time of the experiment, the soil was kept moist. At the end of the growing season (end of April) the remaining leaf cuttings were removed and the number of adventitious bulbs counted, as well as their sizes measured (Fig. 8). In the table below, the result of this one-time experiment have been noted.

DISCUSSION AND CONCLUSIONS

Beforehand it has to be noted that the experiments were almost always conducted with only one bulb per species. The results therefore are more qualitative in character and their quantitative significance is minimal.

Noteworthy are the results with *Albuca* sp., *Galtonia candicans*, *Lachenalia mathewsii* and *L. unicolor*. The general principle in the propagation of bulbs by partitioning is that the newly formed bulbs go dormant at the beginning of the dormant period and they will produce leaves the following growing season. However, the new bulbs of the aforementioned species did not go dormant, but starting sprouting immediately. This seems to be a case of rapid break of dormancy. No clear cause can be given for this phenomenon. It is possible that the partitioned bulbs are subject to stress which causes ethylene production. This ethylene may have contributed to the dormancy break.

Moreover, the duration of the period during which the parts of the bulbs are kept in vermiculite seems to be a limiting factor to success. If this period is too long, the old parts may rot. Also, the newly formed bulbs produced roots that died off after planting. Experiments were conducted with *Eucomis bicolor* and a storage period of 13 and 17 weeks. The period of 13 weeks



Fig. 8. Leaf cuttings of *Haemanthus albiflos*, four months after propagation. From left to the right: bottom part leaf, middle section and top part.

led to the best results; most of the newly formed bulbs did not die off prematurely after planting. Based on these results and descriptions in the literature, a period of 12 weeks seems best.

Besides the duration of storage in vermiculite, the temperature during this period is important for the formation of bulbs. A constant temperature of 20-22° C seems the most suitable. This applies to both summer-growers and winter-growers, as well as for both deciduous and evergreen species. If temperatures are kept lower, there is an increased chance of 'sleepers', i.e., bulbs that do not sprout the first growing season. In the experiments described above, this occurred in *Eucomis bicolor* and in *Galtonia candicans*. If grown on until the following growing season, the bulbs of *E. bicolor* will sprout and form leaves. No differences were obvious between 'sleepers' and the bulbs that did form leaves the first year.

The next question to be raised in propagating bulbs by division is which of the three methods of dividing the bulb is the most suitable: partitioning, scaling or double-scaling. With some plants more than one technique has been applied. In *Galtonia candicans* new bulbs have been formed after both partitioning and double-scaling. In the case of *Eucomis bicolor* and *Haemanthus albiflos* only bulbs formed when partitioning was used, and partitioning and double-scaling respectively. This could indicate that only the buds sprouted. An alternative theory is that, contrary to scaling, in partitioning and double-scaling a part of the basal plate is present. For the formation of new bulbs, sprouting buds or adventitious bulbs, part of the basal plate is needed. This in turn raises the next question: why did adventitious bulbs form from the leaf cuttings of *Haemanthus albiflos*? The scales are nothing less than the bottom part of the leaves. In leaf cuttings, the basal plate is lacking. The possible answer could be that the used *Haemanthus* species had dormant meristems that are activated during the propagation process. This possibility has not been investigated.

That the aforementioned behaviour applies to more than one *Haemanthus* species, can be deduced from the results of experiment with *H. coccineus*. With scaling, several bulbs have formed on the parts 16 months after propagation. With partitioning, new bulbs are visible several months after propagation. In the latter case, it is clear that the bulbs are sprouting buds. This could indicate that the formation of bulbs in scaling is a coincidence. The difference between propagation by scaling and by partitioning could be explained by the fact that there was a difference in dormancy of the meristems, resulting in varying periods of bulb formation.

Noting what has been said before and what has been described in the literature, partitioning is the best method of propagation. Firstly, the parts of the bulb are big enough not to dry out too soon. Moreover, in some genera or species, no adventitious bulbs may be formed. In that case, it is possible that buds sprout. The chance of that is lower with double-scaling and non-existent in scaling.

Based on experience and the literature, the following protocol has been developed for the propagation of bulbs by division. It is suitable for deciduous or evergreen, summer-growing and winter-growing bulbs:

- Propagation method: partitioning.
- Time of propagation: beginning of dormancy.
- Duration of storage in vermiculite (maximum): 12 weeks.
- Ratio vermiculite : water 10:1
- Ratio vermiculite : bulb parts 1:1.
- Storage temperature: 20-25° C.

If bulbs have formed within this period, plant these up immediately. These new bulbs go dormant until the next growing season. Plant in moist soil and place the plants in a shady spot.

It can be concluded that *H. albiflos* can be propagated by taking leaf cuttings. The question which part of the leaf leads to the best result, cannot be answered here due to the differences in the end results being too slight.

From the results and conclusions described above, a few follow-up questions can be formulated:

- What is the reason for the early sprouting in the newly formed bulbs of *Albuca* sp. 10 km *Galtonia candicans*, *Lachenalia mathewsii* and *L. unicolor*?
- In *Haemanthus albiflos*, *H. coccineus* and *Eucomis bicolor* new bulbs only formed when techniques were used which leave a part of the basal plate on the division. This raises the question whether only buds have sprouted or whether adventitious bulbs have formed which need a part of the basal plate.
- In the experiment described a period of storage in vermiculite of 13 weeks has been used. Would partitioning of the bulb at the beginning of the growing season followed by immediate planting up lead to other, better or worse results?
- Can *Haemanthus* species other than *H. albiflos* be propagated by means of leaf cuttings?

- From the experiments on *H. albiflos* it can be concluded that no bulbs are formed from scaling, but only from partitioning or double-scaling. Does this also apply to other *Haemanthus* species?
- In *H. albiflos* the bulbs formed after partitioning or from leaf cuttings grow faster than bulbs raised from seed. A possible cause may be ascribed to 'rejuvenation'; an effect that can be observed with other bulbous plants when propagated by tissue culture.

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Table 1. Summary of results experiments propagating bulbs by division.

Genus (Family)	Technique	Number of bulbs used	Circumference of bulbs used (cm)	Propagation rate per bulb ¹	Ave. Circumference of Bulb(s) Formed ² (cm)
Winter-growers					
<i>Albuca</i> sp. (Hyacinthaceae)	Partitioning	2	6, 9	6	2
<i>Haemanthus albiflos</i> (Amaryllidaceae)	Partitioning	1	12	6	3
	Double-scaling	1	12	6	3
<i>H. coccineus</i> (Amaryllidaceae)	Scaling	6 scales	26	0, 3 ⁴	< 2
	Partitioning	4	14	2	< 2
<i>Lachenalia mathewsonii</i> (Hyacinthaceae)	Partitioning	3	4	3	< 2
<i>L. unicolor</i> (Hyacinthaceae)	Partitioning	1	6	1, 3	< 2
Summer-growers					
<i>Crinum x powellii</i> (Amaryllidaceae)	Scoring	1	20	3	10
<i>Drimiopsis maculata</i> (Hyacinthaceae)	Partitioning ⁴	2	10	9	4
	Partitioning ⁴	1	26	14	23
<i>Eucomis bicolor</i> (Hyacinthaceae)	Scaling	1	22	0	0
	Double-scaling	1	22	0	0
<i>Galtonia candicans</i> (Hyacinthaceae)	Partitioning	1	20	12	8
	Double-scaling	1	20	56	6

¹ Converted to the number of bulbs obtained from one bulb.² Rounded off to whole numbers.³ Number of formed bulbs per scale. Only a limited number of scales have been used from the original bulb.⁴ Experiment done twice, results are average.**Table 2.** Results propagation from leaf parts in *Haemanthus albiflos*.

Part of the leaf/result	Number of bulbs formed	Ave. circumference of bulbs formed
Top	2	≤ 2
Middle	1	4
Bottom	2	3

RHODOHYPOXIS, BEAUTY IN ABUNDANCE**Yashica Singh**National Botanical Institute, Natal Herbarium
Botanic Gardens Road, Durban, 4001 South Africa*See page 86 for color plates.*

Over the grassy zigzagging slopes of the mystical Drakensberg Mountains in the interior of southern Africa, resides the inherent beauty and splendour of some 400 plant genera. Many of these have their centre of diversity in the Drakensberg. One such genus is *Rhodohypoxis*. In the spring and summer months, the rose-colored, dainty flowers of *Rhodohypoxis* appear en masse (Fig. 1), staining the grassy hills and rocky outcrops. This small yet distinctive group of hardy perennial herbs has also found its place among the pot and landscape ornamentals in Europe, the United Kingdom, the United States and Japan, as it is excellent for alpine gardens. The purpose of this account is to introduce this fascinating genus, to reveal the characters of wild species, and to highlight their decorative potential.

Rhodohypoxis belongs in the Hypoxidaceae or star-lily family and is a close ally to the genus *Hypoxis* (Fig. 2). Plants of *Rhodohypoxis* were placed in *Hypoxis* up until 1914, when Gert Nel recognised that these rose-colored flowering herbs were in fact different from their yellow star-flowered counterparts. Nel established the genus *Rhodohypoxis* to accommodate the 'Hypoxis' plants with white, pink or red flowers. At that stage, he recognised two species, *R. baurii* and *R. rubella*. The prefix *Rhodo-* refers to the rose-colored flowers of the genus and *hypoxis* to the structural similarity shared with plants in that genus. *Rhodohypoxis* differs from *Hypoxis* by virtue of its white, pink or red flowers, the presence of a perianth-tube, and stamens hidden and lacking well-defined filaments (Nel, 1914). In addition to this, Hilliard and Burt (1978) pointed out that in *Rhodohypoxis* the 3 inner perianth-segments flex inwards to meet at the throat of the flower. Figures 3a & b illustrate the structural distinction between flowers of these 2 genera. A generic description of *Hypoxis* is given in Veld & Flora (Singh, 1999).

Rhodohypoxis is a small genus of 6 species with a distribution centered in the Eastern Region of the Drakensberg (Fig. 4). *R. baurii* and *R. milloides* have a wider distribution as they also inhabit outlying ranges of the Drakensberg, including the Mawahqua, Insizwe, Insikeni, Currie, Ngeli and Tabankulu Mountains in the Eastern Region of South Africa. The most

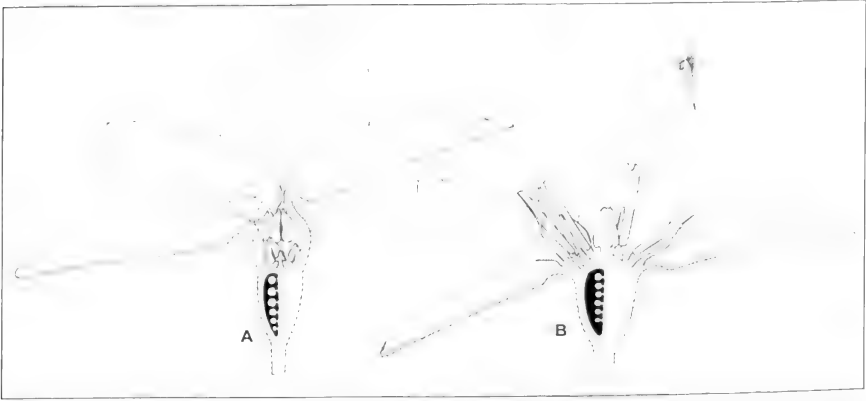


Fig. 3. Half flower drawings showing structural differences between A. *Rhodohypoxis baurii* var. *platypetala* and B. *Hypoxis setosa*

variable taxon, *R. baurii* var. *confecta*, is fairly widespread from the Eastern Cape Province through the corridor formed by the KwaZulu-Natal and Free State Provinces in South Africa, and Lesotho. Its distribution dwindles along the western border of Swaziland into South Africa's Northern Province. *R. thodiana* and *R. incompta* have a very narrow distribution restricted to the KwaZulu-Natal-Lesotho border at Giant's Castle and Sani Pass, respectively. These two KwaZulu-Natal Drakensberg endemics are considered to be near threatened and are protected in the uKhahlamba Drakensberg Park (Scott-Shaw, 1999).

On the Drakensberg itself, *Rhodohypoxis* plants grow in the grassy slopes and rock outcrops of the Little Berg and Main Escarpment. The vegetation belt of the Little Berg is subalpine, 1800-2800m, while that of the Main Escarpment is alpine, ca. 2800-3500m (Killick, 1990). The mountain is typified by black clay soils, cool to mild temperatures, fairly wet summers and relatively dry winters. Frost occurs almost daily in winter. Fire and wind also contribute to the ecological and floristic preservation of the mountain. Plants of *Rhodohypoxis*, like those of most monocots in the Drakensberg, are able to withstand frost and fire by means of an underground rootstock and seasonal growth pattern. In the Little Berg, *Rhodohypoxis* is a distinctive component in the predominantly short grasslands. The plants grow in peaty soil among the grasses and on rock surfaces, where they form carpets. These grasslands are intrinsically diverse, containing several species of forbs and grasses. On the Main Escarpment, *Rhodohypoxis* is restricted to bogs and sponges, where the soil is regularly moist to wet (Killick, 1990).

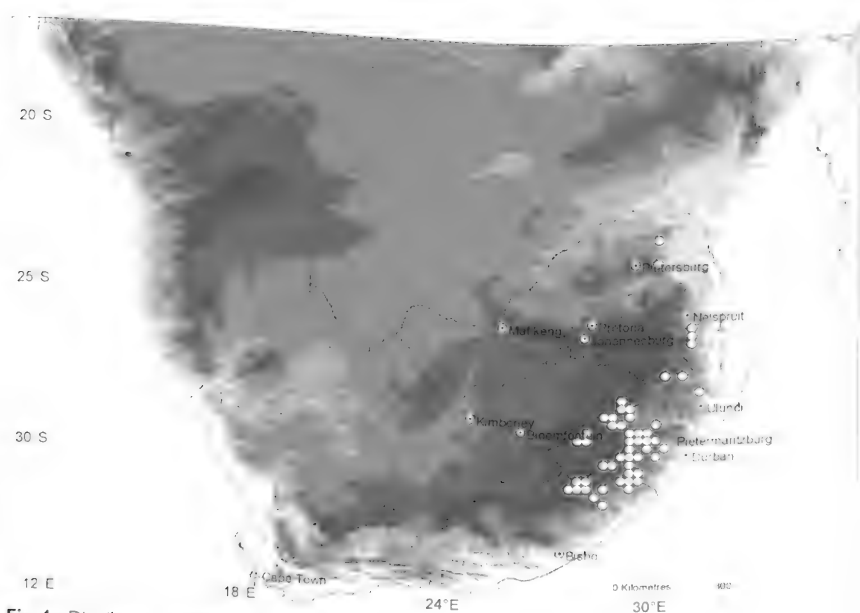
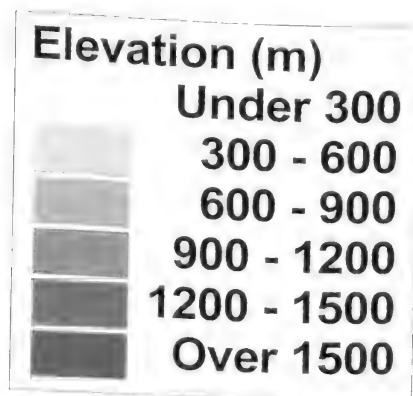


Fig. 4a. Distribution of *Rhodohypoxis*, centred in the Eastern Region of the Drakensberg.



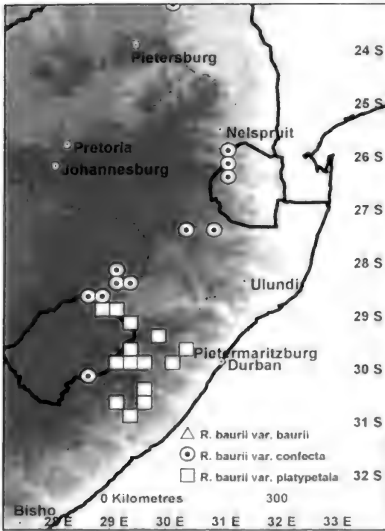


Fig. 4b. Distribution of the widespread *R. baurii* varieties extends to outlying ranges of the Drakensberg.

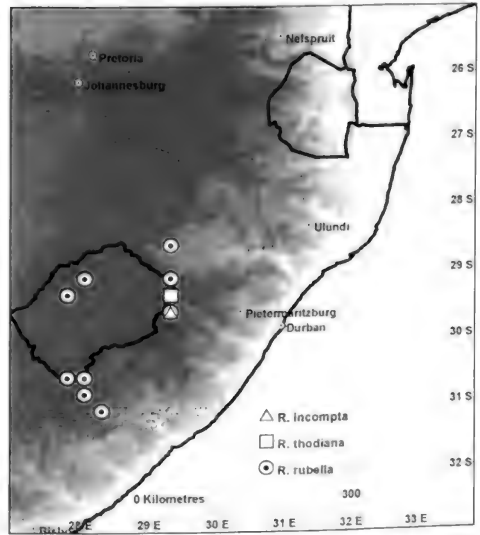


Fig. 4c. Distribution of the near threatened endemics *R. incompta* and *R. thodiana* and the more widespread *R. rubella*.

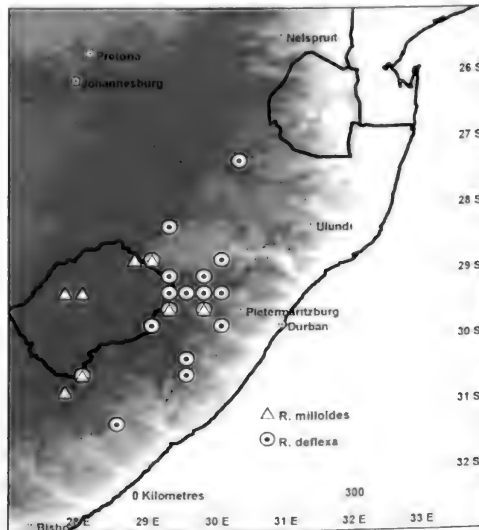


Fig. 4d. Distribution of *R. milloides*, extends to the outlying ranges of the Drakensberg, and *R. deflexa*, confined to high altitudes in Lesotho and surrounding Provinces in South Africa.

PLANT STRUCTURE

Plants of *Rhodohypoxis* are small perennial geophytes, to 15cm in height, that die back in winter. The underground vertical rootstocks or rhizomes are joined to one another by stolons. Five to ten leaves arise from the apex of each small rhizome. These triangular, linear-lanceolate to filiform leaves are bright or dull green and are usually hairy to a varying degree among taxa and age of the leaves. The number of inflorescences per plant is proportional to the number of leaves with up to ten per plant. The long and erect peduncles bear a single flower, but may be forked to support two flowers. Flowers consist of six perianth-segments in two series; the three inner ones being slightly narrower than the outer ones. The perianth-segments are either white, pink or red, or white and pink variegated. They fuse distally to form a short perigone tube. Just above the tube, the inner segments flex inwards to converge, closing the throat of the flower. Above the throat, the perianth-segments spread outwards and are persistent following fertilization. Six stamens arranged in two series arise from the perigone tube; the outer set lies above the inner. Anthers are hidden below the perianth-segments and are sessile to subsessile. The trilocular ovary is beaked or beakless and contains 4-6 ovules arranged axially in each locule. A very short style bears a 3-lobed stigma. The fruit is a thin, papery capsule with circumcissile dehiscence as in *Hypoxis*. In some taxa, the fruit breaks up irregularly below the apex. Seeds are round to oval, black, shiny and brittle. Plants flower between October and February.

Notes on species based on detailed site studies done by Hilliard and Burt (1978):

Rhodohypoxis baurii var. *baurii* (Fig. 5). Widespread from Eastern Cape through to Northern Province, concentrated in KwaZulu-Natal. Leaves narrow, suberect and dull green. Flowers characteristically deep red, rarely white. Habitat moist, cliff faces and rocks. Hybridises with *Hypoxis parvula* var. *parvula*.

Rhodohypoxis baurii var. *confecta*. Widespread from the Eastern Cape to Northern Province. Leaves erect and bright green. Flowers white or pink with some reds; some flowers opening white, changing to pink and then to red with age. Habitat moist, grassy slopes, rock outcrops or plateau summits. Hybridises with *R. deflexa*, *R. thodiana* and *Hypoxis parvula* var. *parvula*.

Rhodohypoxis baurii var. *platypetala* (Fig. 6). Concentrated in KwaZulu-Natal. Leaves broad and flat, erect or spreading, grey green. Flowers mainly white, occasionally pale pink. Habitat dry, stony soil on rock sheets, rocky grassland. Hybridises with *R. milloides* and *Hypoxis parvula* var. *albiflora*.

Rhodohypoxis milloides. Distributed from the Eastern Cape to the northern border of KwaZulu-Natal. Leaves linear to lanceolate, subglabrous and bright green. Flowers crimson, rarely pink or white. Habitat marsh. Hybridises with *R. baurii* and *Hypoxis parvula* var. *albiflora*.

Rhodohypoxis deflexa. Occurs in Eastern Cape, KwaZulu-Natal and Lesotho. Leaves linear-lanceolate. Flowers bright reddish-pink or pale pink, very small. Habitat marsh.

Rhodohypoxis thodiana. Localised in Giant's Castle area at the KwaZulu-Natal-Lesotho border. Leaves lanceolate and flat. Flowers pale pink, scented. Habitat moist, grassy slopes. Hybridises with *R. rubella*.

Rhodohypoxis rubella. Occurs in Eastern Cape, KwaZulu-Natal and Lesotho. Miniature plants to 5cm. Leaves triangular-filiform and subglabrous. Flowers bright pink, rarely pale pink to white, very small. Habitat moist, stony soil on rock sheets, seasonal pools. Hybridises with *R. thodiana*.

Rhodohypoxis incompta. Localised at Sani Pass area at the KwaZulu-Natal-Lesotho border. Leaves triangular-filiform, subglabrous. Flowers pink. Habitat, wet, gravelly soil on rocks, edges of grass or sedge tussocks on sandstone rock sheets.

GROWING RHODOHYPOXIS

At least 12 varieties of *Rhodohypoxis* are available in the United Kingdom, Europe, the United States and Japan. Species in the trade include *R. baurii*, *R. milloides*, *R. deflexa* and *R. thodiana*, with *R. baurii* the most common. Varieties of *Rhodohypoxis* sell for \$2.99–\$6.75 in the States and £1.50 to £4.00 in the UK per 4 inch pot. As white, pink or red flower color (dependent on the age of the flower) in *R. baurii* var. *confecta* is displayed on a single plant (Fig. 7), this offers a brilliant mix in one pot. The perianth-segments are persistent following the reproductive phase of the flower and thus provides the desirable advantage of a long flowering period. Cultivated hybrids of *Rhodohypoxis baurii* and *Hypoxis parvula*, named X *Rhodoxis hybrida* B. Mathew (Mathew, 1998) are popular pot plants in the United Kingdom (B.L. Burt, Royal Botanic Garden, Edinburgh, pers. com. 1999).

It is rather difficult to grow *Rhodohypoxis* in warm and humid conditions like those experienced in the coastal region of South Africa. Plants are adapted to seasonal rainfall and, once established, require no watering during the dry season. They are also frost and snow hardy and thus are well suited to northern hemisphere gardens. Vegetative propagation is easily achieved by division of the underground stolons that hold the plants

together in a clump. Rhizomes are small and require shallow planting in well-drained loam soil. Seed germination is slow, requiring 30–60 days.

Rhodohypoxis plants are suitable as pot plants as well as for bedding in cool climates. Flowers of *Rhodohypoxis* provide good color in the landscape, especially beautiful when grown *en masse*.

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A REVIEW OF *CALOCHORTUS* (MACDONALD; PP. 41-58)



Fig. 1. *Calochortus tiburonensis* from Marin County, California.



Fig. 2. *Calochortus ownbeyi*.



Fig. 3. *Calochortus pringlei*.



Fig. 4. *Calochortus fuscus*.



Fig. 5. *Calochortus ghiesbreghtii*.



Fig. 6. *Calochortus barbatus* var. *chihuahuensis* from Chihuahua, Mexico.

A REVIEW OF *CALOCHORTUS* (continued)

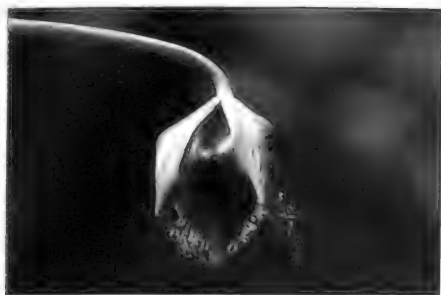


Fig. 7. *Calochortus marcellae* from San Luis Potosi, Mexico.



Fig. 8. *Calochortus nigrescens*.



Fig. 9. *Calochortus hartwegi* from Zacatecas, Mexico.



Fig. 10. *Calochortus purpureus* from Durango, Mexico.

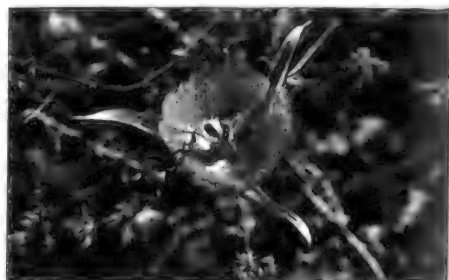


Fig. 11. *Calochortus fimbriatus* from Santa Barbara County, California.

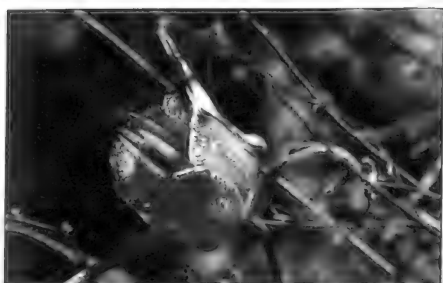


Fig. 12. *Calochortus fimbriatus* from Santa Barbara County, California.

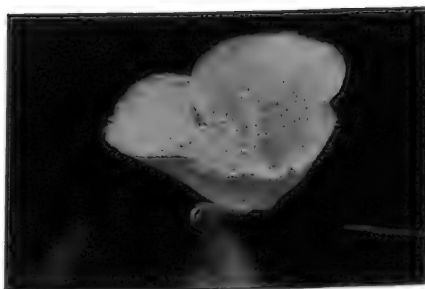


Fig. 13. *Calochortus weedii* var. *peninsularis* from the Baja Peninsula, Mexico.

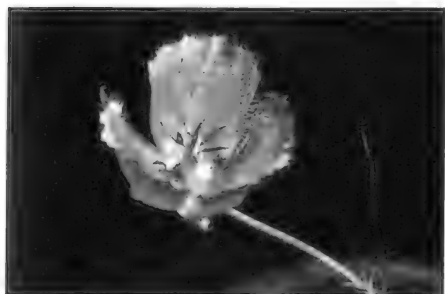


Fig. 14. *Calochortus weedii* var. *intermedius* from Orange C San Luis Obispo County, California.

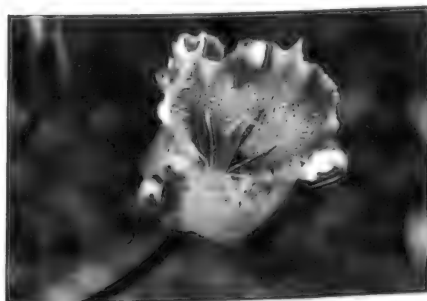


Fig. 15. *Calochortus plummerae* from Riverside County, California.



Fig. 16. *Calochortus obispoensis* from San Luis Obispo County, California.

EUCOMIS—AN ELITE ÉCLAT OF EXCELLENCE (GOVENDER, ET AL; PP.59–64)



Fig. 1. *Eucomis autumnalis*: the 'pineapple' inflorescence.



Fig. 2. *Eucomis pole-evansii*: plants of regal stature, with plain green leaves and yellow-green flowers.



Fig. 3. *Eucomis schiffii*: a diminutive mountain beauty, with variegated leaf and flower coloration.



Fig. 4. *Eucomis montana*, leaf bases speckled with purple coloration.



Fig. 5. *Eucomis bicolor*, variegation in flower color, promoting its ornamental beauty.



Fig. 6. *Eucomis humilis*, a species with a combination of plain green leaves and purple flowers.



Fig. 7. Solitary bees reaping rewards for a job well done in *E. autumnalis*.



Fig. 8. *Eucomis regia*, a winter rainfall endemic.

EUCOMIS—A HORTICULTURAL REVIEW (HARTLEY & DE HERTOIGH; pp. 65-70)



Fig. 1. Example of a *Eucomis* hybrid as a flowering potted plant.



Fig. 2. Example of foliage coloration of a *Eucomis* hybrid in the visible bud stage of flower development.

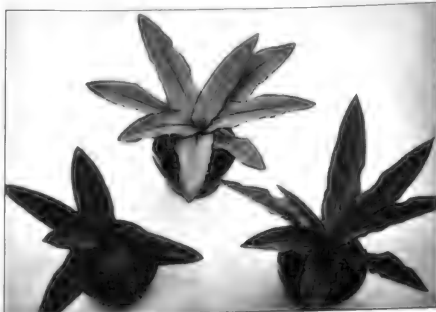


Fig. 3. Examples of foliage coloration of *Eucomis* hybrids.

RHODOHYPOXIS (SINGH; PP. 162–168)



Fig. 1. *Rhodohypoxis baurii* var. *confecta* forming a colorful cluster on rocky precipices at Sentinel Peak, a scenic part of the Free State Drakensberg.



Fig. 2. *Hypoxis costata*, yellow flowers with perianth-segments free and stamens visible.

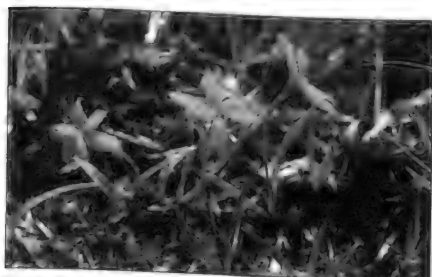


Fig. 5. *Rhodohypoxis baurii* var. *baurii*; deep red flowers dot the slopes of Jonkershoek, Eastern Cape Drakensberg.



Fig. 6. White flowers of *R. baurii* var. *platypetala* in KwaZulu-Natal Midlands.



Fig. 7. *Rhodohypoxis baurii* var. *confecta*, red, pink and white flowers on a single plant.

All photos by Y. Singh

AMARYLLIDACEAE OF THE EASTERN CAPE PROVINCE (McMASTER; pp. 97–106)



Fig. 2. *Boophone disticha*



Fig. 3. *Brunsvigia gregaria*



Fig. 4. *Ammocharis coranica*



Fig. 5. *Crinum macowanii*



Fig. 6. *Crinum campanulatum*



Fig. 7. *Cyrtanthus contractus*

*All photographs by
Cameron McMaster*

AMARYLLIDACEAE OF THE EASTERN CAPE PROVINCE (continued)



Fig. 8. *Cyrtanthus obliquus*



Fig. 9. *Cyrtanthus huttonii*



Fig. 10. *Cyrtanthus smithiae*



Fig. 11. *Nerine filifolia*



Fig. 12. *Nerine angulata*



Fig. 13. *Haemanthus albilos*

SIPHONCHILUS AETHIOPICUS (CROUCH, ET AL; PP. 115–129)



Fig. 1. An hermaphroditic (bisexual) flower of *Siphonochilus aethiopicus*, larger and more horticulturally appealing than the female flower.



Fig. 2. The less-showy female flower, with a narrow throat leading to the basal stigma.



Fig. 4. Zulu traditional herbalist (Nyanga) Tr. Dr Mthethwa with a cultivated plant of Wild Ginger at his home near Ongoye.



Fig. 5. Rhizomes traded as *indungulo* in the Ezimbuzini medicinal plant market, Durban. The fusiform tubers have been removed prior to marketing.

All photos by N. Crouch.

A NEW SPECIES OF *CRINUM* (LEHMILLER; PP. 130–133)



Fig. 1. Site location of *C. razafindratsiraea* near Ambohimasimbola, Madagascar. Alfred Razafindratsira (center) with assistants, 30 November, 1996.

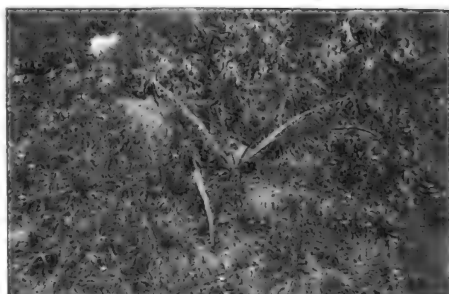


Fig. 2. *Crinum razafindratsiraea* near Ambohimasimbola, Madagascar, 12 January, 1998.



Fig. 3. *Crinum razafindratsiraea* collected near Ambohimasimbola, Madagascar, and cultivated in Southeast Texas, July, 1999. Note "nodding" buds prior to anthesis.



Fig. 4. *Crinum razafindratsiraea*, same umbel as Figure 3, only one day later.

NERINE REHMANII (CRAIB; PP. 134–136)



Fig. 1. Group of *Nerine rehmanii* on a rocky ridge in the suburb of Kensington, Johannesburg, South Africa. Most of plants in this group are in seed (early March 2000).

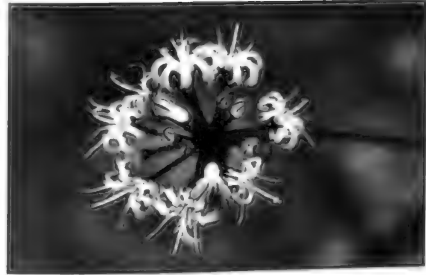


Fig. 2. Detail of an umbel of *N. rehmanii* flowers.



Fig. 3. Detail of *N. rehmanii* in seed..

Above photos by Carol Knoll

ECOLOGY OF *STRUMARIA GEMMATA* (CRAIB & BROWN; PP. 137–139)



Fig. 1. The spectacular dolerite domes and grassy slopes of the Andriesberg provide a habitat for a wide range of plant species. Below the domes, mossy pockets of soil may remain damp for weeks in summer. They provide an ideal habitat for the germination of seed and often carry large colonies of *Strumaria gemmata*.



Fig. 2. In January and February, the lemon-flowered umbels of *S. gemmata* may be found in widely dispersed colonies in pockets of soil across the domes

Above photos by Laurian Brown

MASSONIA JASMINIFLORA (CRAIB & KNOLL; PP. 140–143)

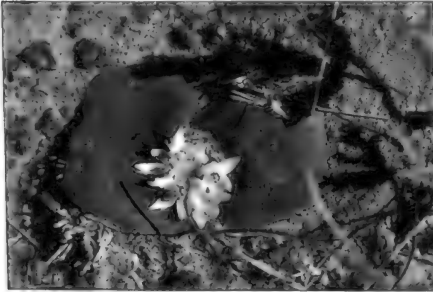


Fig. 1. Details of *Massonia jasminiflora* in flower in sandy pebbly soil near Wolmaranstad, Northwest Province late May 2000.



Fig. 2. Leaves damaged by the hooves of grazing sheep at Wolmaranstad



Fig. 3. Closeup of flowers and leaves of plants near Wolmaranstad.



Fig. 4. Buds and flowers of plants from the Tarkastad area.

Above photos by Carol Knoll

CORYDALIS MAGADANICA (BERKUTENKO & LUMSDEN; PP.144–150)



Fig. 1. *Corydalis magadanica* in habitat. Photo by D. Plotnikov.



Fig. 2. *Corydalis magadanica* in cultivation.

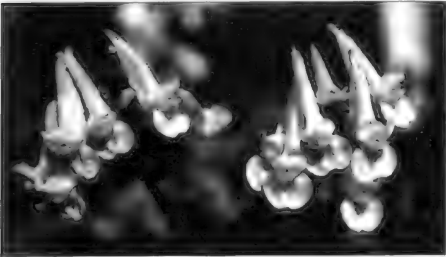


Fig. 3. Flowers of *Corydalis magadanica*.

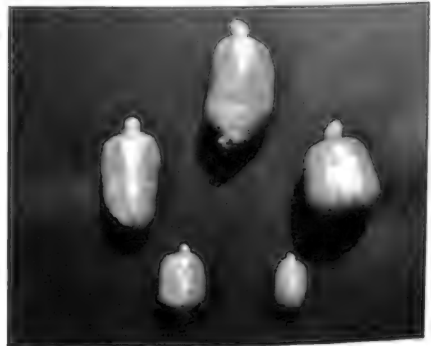


Fig. 4. Tubers of *Corydalis magadanica*.

Above photos by Harry Lumsden except where noted.

Fritillaria imperialis (KHANIKI; PP. 101–155)

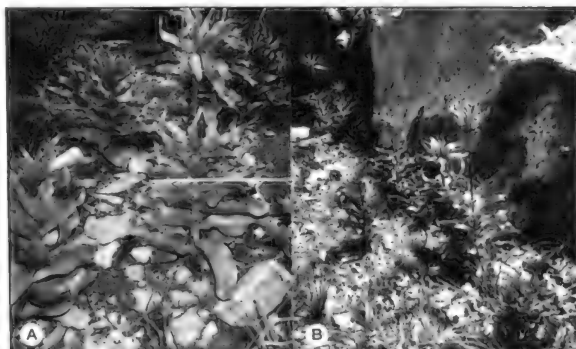


Fig. 1. *Fritillaria imperialis*. A. Arak province: Kuh-e Sefidkhani. B. Hamadan province: Elwand mountain.



Fig. 2a. *Fritillaria imperialis*; Esfahan: Khonsar, Golestan Kuh, 2600–2800 m.



Fig. 2b. *Fritillaria imperialis*; Nectary in *F. imperialis*.

FRITILLARIA SUBGENUS (KHANIKI; PP. 156–161)



Fig. 1a. See caption below.



Fig. 1b. See caption below.



Fig. 1c. See caption below.

Fig. 1a, 1b, 1c, 1d, 1e, and 1f. *Fritillaria persica* in Iran. A. C. Population GBK56. B. Population GBK58. D, F. Population GBK90. E. Population GBK57. GBK stands for the name of collector and author, Gholamreza Bakhshi Khaniki. See specimens examined in text for locality.

FRITILLARIA SUBGENUS (continued)



Fig. 1d. See caption on page 95.



Fig. 1e. See caption on page 95.



Fig. 1f. See caption on page 95.

AMARYLLIDACEAE OF THE EASTERN CAPE PROVINCE

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See pages 86–87 for color plates.

EASTERN CAPE, SOUTH AFRICA

South Africa is world renowned for its indigenous flora, and particularly the flora of the Western Cape Fynbos biome in the winter rainfall region. Geophytes form an important part of this flora and Cape bulbs are known throughout the world for their diversity and beauty. Most tourists and travellers interested in our indigenous flora visit Cape Town and the surrounding regions, particularly during the spectacular spring flower season up the West Coast and in Namaqualand. Very few visitors extend their journey to the lesser known parts of the Eastern Cape (Fig. 1) east of Port Elizabeth — a region of primarily summer rainfall that in terms of bio-diversity, numbers and variety of wild flowers, including bulbs, almost rivals the Western Cape.

CLIMATE AND TOPOGRAPHY OF THE EASTERN CAPE

The province contains a vast variety of landscapes, from the stark Karoo (the semi-desert region of the central interior) to mountain ranges and gentle hills rolling down to the sea. The climate and topography give rise to the

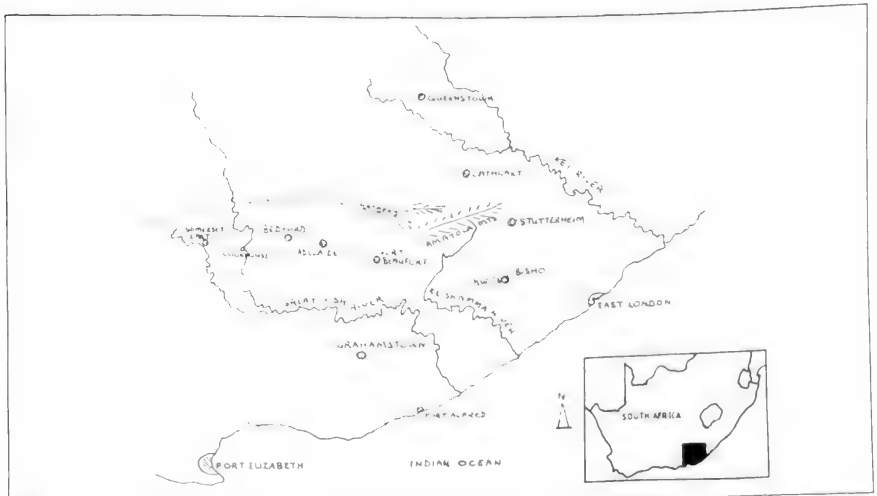


Fig. 1. The Eastern Cape of South Africa

great diversity of vegetation types and habitats. Except along the coast and along the southern slopes of the mountain ranges that form a series of escarpments, the annual rainfall seldom exceeds 500mm and occurs mostly in summer. Rainfall in summer comes in the form of both thundershowers and prolonged drizzle and mist as weather fronts move through the region from west to east. Particularly along the coast and on the southern mountain slopes, mist precipitation is significant. Some winter rain does fall occasionally and snow sometimes occurs on the high mountain ranges. Frost will occur regularly between May and September in areas above 1000 meters. The topography is hilly and in places rugged, with a series of mountain ranges extending from east to west that rise to altitudes of up to 2000 meters. Considerably drier areas of rain shadow occur to the north of the escarpments as well as in a number of deep river valleys, such as the Great Fish River valley, that bisect the region. Fire is an integral part of the grassland ecology, occurring mainly in early spring when the moribund grass is burnt to make way for spring growth. Some early flowering *Cyrtanthus* species and many ground orchids are stimulated by fire to flower.

The fact that the Eastern Cape lies in the region of transition between the winter rainfall biome and the summer rainfall regions of East and Central Africa, is a feature that makes it unique. Elements of both vegetation zones are present. For instance typical West Cape genera like *Ixia* and *Strumaria* each have their most easterly representatives in this region, i.e. *Ixia orientalis* ranges as far east as Cathcart, and *Strumaria gemmata* as far as the mountains in the Sterkstroom district where they endure extremely cold and dry winters. *Haemanthus coccineus* occurs as far east as the Keiskamma River near East London. On the other hand, this region is the western boundary of summer rainfall species such as *Haemanthus montanus* and *H. humilis* ssp. *humilis*, which extend from the Eastern Cape through Natal and into the northern provinces.

A further anomaly of this transition zone between winter and summer growing species, is that some bulbs retain a summer dormancy. For instance the *Brunsvigia* species, although growing in a summer rainfall region, follow a growth pattern almost akin to winter rainfall species. Leaves appear after flowering in late summer, persist through winter, and the plants go dormant in early spring. A number of other bulb species in the Eastern Cape exhibit similar growth patterns. *Massonia jasminiflora* is summer dormant and flowers in winter. *Freezia laxa* is an example of a bulb that grows in winter, flowers and seeds in spring and early summer, and disappears entirely in

mid-summer. The fact that it grows in full shade in forest probably affords it the protection it needs against winter elements. *Veltheimia bracteata* flowers in early winter and has a short dormancy in midsummer.

The diverse climatic and topographical features of the Eastern Cape give rise to a very wide range of vegetation types embracing coastal dune forest, acacia savannah, various types of grassland ranging from lowland mixed grassveld to highland sour grassveld, valley bushveld and lush Afromountain forest. Within each vegetation type special circumstances such as aspect, slope, soil type, wetlands, stream banks, cliffs, ravines, gorges etc. give rise to an infinite variety of microclimates and habitats to which particular species are adapted. Consequently, a very large number of species occur in the Eastern Cape, some extremely localised and others widespread. It is interesting that in those species that are more widely spread, considerable variation occurs which often gives rise to questions as to their status. Are they geographic forms of a particular species or should they be given specific status, such as the *Haemanthus humilis/carneus* complex and the many varieties of *Eucomis autumnalis*? This is an ongoing debate in which both amateurs and botanists participate.

AMARYLLIDACEAE

Almost all the bulbous genera that occur in Southern Africa are represented in the Eastern Cape. The region is particularly rich in Amaryllidaceae, some species being endemic. Both *Clivia miniata* and *Clivia nobilis* from the coastal regions have become exceedingly scarce as a result of poaching from wild populations. The ubiquitous *Boophone disticha* (Fig. 2) has flowering times of different populations varying from August to November. A particularly robust form with long straight leaves occurs in the Kei River Valley. The bulb scales are extensively used during initiation rites by the Xhosa people to treat circumcision wounds, consequently the bulbs are heavily exploited. *Brunsvigia* is represented by two species — *B. gregaria* (Fig. 3) and *B. grandiflora*. Both are widespread, occurring from the coast to the high mountains. *B. gregaria* varies from pale pink in the eastern and southern populations to bright scarlet in the drier regions of the Karoo. Inland populations flower in February, while those near the coast flower as late as mid-April. Because of its upright leaves, *B. grandiflora* has been severely affected by grazing livestock. This magnificent plant is now confined to small areas where livestock has been excluded by fences, such as road reserves and areas adjacent to arable land.

The most widespread and common amaryllid is the beautiful *Ammocharis coranica* (Fig. 4). It is stimulated to flower by fire and spectacular stands of blooms occur soon after early spring burns. Like *B. gregaria*, westerly populations are darker in color. Although extremely rare, pure white specimens of both *B. gregaria* and *A. coranica* do occur in the wild. *Scadoxus puniceus* is also widely distributed, ranging from lowland acacia veld to the summits of the high mountains. It flowers in spring and is always confined to shady, sheltered spots under trees and bushes or between boulders. On the other hand *Scadoxus membranaceus* has a very restricted distribution, being confined to dense coastal forests where it grows in deep shade.

Crinum is represented by four species in the Eastern Cape. *C. moorei* occurs in the frost-free coastal dune forest. *C. macowanii* (Fig. 5) is widespread in the grassland and bushveld areas with colder and drier winters, but it is also severely threatened by overgrazing. *C. lineare* is restricted to the Port Elizabeth area where it grows in sandy soil in coastal fynbos. The habitat of this rare localised species is severely threatened by urban development. *C. campanulatum* (Fig. 6) is endemic and is confined to shallow seasonal pans (referred to locally as "vleis") in the Peddie and Bathurst districts, which bake hard in the dry season when there is no sign of a bulb. They are opportunistic in that they will flower only when the pans fill with water. In good seasons the mass flowering of this spectacular crinum is a breathtaking sight. They rapidly set seeds that drop and float on the water. They germinate when they come into contact with the mud as the water evaporates after the rains have passed. While these crinums vary mostly from dark to pale pink, one pan in the Peddie district has paler colors ranging to pure white.

CYRTANTHUS

The region is particularly rich in *Cyrtanthus* species, some endemic to the region and some as yet undescribed. Dyer (1939) states that with the concentration of species in the Eastern Cape, it may be regarded as the headquarters of the genus. Most species put out their flowers before their leaves, but some are evergreen. The most widespread is *C. contractus* (Fig. 7), which extends from inland areas of the Eastern Cape northwards. It seems to have no preference as to habitat, occurring sporadically in open grassland where it flowers in October, or earlier if stimulated by fire, its brilliant red umbels being most conspicuous in its usually drab surroundings.

Another species of the open grassland referred to as *C. mackenii* var. *cooperi* occurs southwards from Stutterheim, where it overlaps *C. contractus*. It is the earliest of the genus to flower in this area with sparse dull yellow to pinkish flowers. Although widespread, it favours marshy ground where large populations are concentrated, making an impressive sight in early August. This species is referred to as *C. ochroleucus* in the book by Batten & Bokelmann "Flowering Plants of the Eastern Cape". *C. ochroleucus* is, however, the name of a species from the West Cape which it resembles, but which does not occur here (Dyer, 1939). It is difficult for me to accept that this *Cyrtanthus* is a variety of *C. mackenii*, the well known garden subject also called Ifafa lily. Both in habitat and growth pattern, it is very different from *C. mackenii* which is evergreen and has many shiny dark green leaves with bright yellow flowers. *C. mackenii* occurs along the banks of streams in full shade in patches of frost-free coastal forest, never occurs in open grassland, and multiplies prolifically by splitting of bulbs forming large clumps at the edges of pools. In contrast, '*C. mackenii* var. *cooperi*' almost never splits (it has single bulbs), is fully deciduous, and has only one or two grey-green leaves. The distribution of the two species does not overlap. I believe some revision needs to be done to clarify the status of *C. mackenii* var. *cooperi*.

Another evergreen species occurring in wooded streambeds near the coast is *C. brachyscyphus*. This is an attractive, free-flowering species, with small bright red flowers and rapid vegetative reproduction, making it an ideal garden subject. Occurring in the same areas, but favouring south facing cliffs and rock ledges, is the beautiful *C. sanguineus* with wide-flaring large trumpet-like flowers and partly exposed bulbs.

Pride of place amongst the *Cyrtanthus* of the Eastern Cape must go the magnificent *C. obliquus* (Fig. 8). No wonder it featured on the cover of *Herbertia* Vol. 52 (1997). It always occurs on exposed rocky outcrops in drier areas where its bulbs are crowded between the rocks or clinging to steep cliffs. It is evergreen with large grey-green strap-like leaves. Its large brilliant orange and green flowers in mid-summer in the middle of such rugged surroundings, are a never-to-be-forgotten sight. The main requirement in cultivation is excellent drainage with bulbs at least halfway out of the soil. It is fairly widely distributed in the Eastern Cape, extending from the Knysna district eastwards into Natal.

The high mountains of the region where the soil is always cool to cold, are home to a number of striking and interesting species of *Cyrtanthus*. *C. breviflorus*, a bright yellow species, occurs in massed populations in damp

but sunny spots, along mountain streams where it flowers in early spring. Much less common is the bright scarlet *C. rotundilobus* which occurs high on the Bosberg mountains near Somerset East. This striking species with dense, many flowered umbels, flowers in December. In contrast to similar species it has numerous leaves which develop before flowering. *C. tuckii* var. *viridilobus* occurs sparsely in the high mountain grassland — a beautiful species with bright green tips to its orange flowers. *C. suaveolens* is a dainty maroon colored scented species with recurved perianth lobes occurring only on the summits of the Amatola mountains where it flowers in October. It is one of the few *Cyrtanthus* that have a solid peduncle. It is a hardy species that adapts well to cultivation. The most beautiful of the mountain *Cyrtanthus* and one with a very specialised habitat, is another endemic to the Amatola, Katberg and Winterberg ranges, *C. huttonii* (Fig. 9). This glorious species, with its large, almost iridescent dark orange blooms and purple bracts born on tall peduncles, occurs in moist crevices along mountain streams and waterfalls or on cliffs where there is continuous water seepage through its roots. Occasionally it may be found in permanently wet areas on steep mountain slopes in the Amatola and Katberg ranges. It flowers in mid-summer. While it germinates readily and the juvenile plants survive easily, its habitat is almost impossible to reproduce. It represents a challenge to flower in cultivation. What a reward it will yield to those who are successful!

Two interesting related species with spiral leaves occur in much drier and inhospitable regions of the East Cape. The diminutive *C. helictus* occurs in sandy soil in sparse, dry grassland in isolated populations from Cathcart northwards to Sterkstroom. However these populations consist of vast numbers of individuals, the low growing flowers being massed in a spectacular display in a good season. The tiny tightly curled corkscrew leaves are seldom taller than 6cm and the trumpet-shaped white flowers with pink candy stripes are born singly on stems no higher than 10 cm. It flowers in October. A larger and very showy species with spiral leaves and large multiple flower-heads, *C. smithiae* (Fig. 10), occurs in hot and dry sandy flats in bushveld, on either side of the Great Fish River between Cookhouse and Fort Brown. The Cookhouse populations are cream colored with greenish candy stripes while those from Fort Brown are various shades of pink with darker pink stripes. Because of the uncertainty of the rainfall, successful flowering and seed setting is not achieved every year. However, the bulbs seem quite content to lie dormant through the dry periods, bursting into life and completing a short reproductive cycle if it rains any time between November and January.

Two further closely related species with pale candy striped flowers are found in the southern coastal strip of the region. *C. loddigesianus* occurs in the dune grassveld between Port Elizabeth and East London. It has fairly robust upright leaves and 1 - 3 pale cream flowers with green candy stripes born horizontally to almost erect. In contrast, a closely related but much smaller plant, *C. clavatus*, with narrow, slightly twisted leaves and pale pink candy stripes, occurs further inland between Port Elizabeth and Grahamstown in open grassland. The flowers are very similar to *C. helictus*, but can be distinguished from this species in that the leaves are not tightly spiralled and there may be up to four flowers on a peduncle. Both *C. loddigesianus* and *C. clavatus* have leaves when in flower in January.

At least another three species awaiting clarification occur in the East Cape. A January-flowering small orange variety with two very narrow leaves born at the same time as the flowers, occurs on the high hills around Grahamstown. Dr. Dee Snijman of the National Botanical Institute, Cape Town, (personal communication) has offered the opinion that these may match the type material of *C. parviflorus*, a species listed in Dyer (1939), but omitted from the Review by Reid and Dyer (1984) where it has been included with *C. brachyscyphus*. Dr. Snijman will not, however, be committed in respect of two other dark orange colored species occurring in the Stutterheim district in the same locality, but flowering a month apart on the high hills above the Great Kei River. The smaller of the two has a narrow perianth tube with a slight dilation near the base and sharply recurved lobes. It flowers in December. The second species flowers from late January through February. It is larger with slightly broader leaves, also born at the same time as the 3 - 5 flowers, which are trumpet shaped. It is hoped that a diagnosis will be available soon and that the status of these puzzling *Cyrtanthus* species will be cleared up.

NERINE

Nerine is a genus which is very well represented in the Eastern Cape. Most species make excellent garden subjects and require little effort to grow. *N. masoniorum*, which occurs in the area formerly known as the Transkei, is the smallest of the group. It has tiny compact flower heads and fine filiform leaves. It is the earliest to flower, from late January. Bulbs multiply profusely. Its status in the wild was reviewed by Dold *et al* (2000). *N. gibsonii* occurs in the highlands of the Transkei between Lady Frere and Cala. Its habitat is severely degraded and, as it is confined to such a small area, it is possibly

doomed to extinction. It is remarkable in that the color of this species in the wild varies from pure white to purple with all the shades of pink in between, with no one color dominant. Leaves are filiform, fairly robust, both leaves and flowers being of a similar shape and size to *N. angulata*.

Nerine filifolia (Fig. 11) occurs widely in various spots in the East Cape always between rock slabs or in shallow poorly drained soil overlaying rock slabs. It flowers in April and is almost evergreen. A diagnostic feature is the hairy peduncle. *N. filamentosa* is a very distinct species with a limited range in the Cathcart district where it grows in similar habitats to *N. filifolia*, although the species do not overlap. It has very fine filiform, deciduous leaves, and a smooth peduncle. The large flower heads are arranged in a sparse, flattened umbel. The flowers have strongly recurved tepals and extremely long filaments. It flowers from early February.

Nerine angulata (Fig. 12), from riverbanks and seepage areas in the highlands of the Amatola and Bosberg mountains from Stutterheim and Cathcart to Somerset East, is the largest species with filiform leaves in this region. An occasional pure white specimen is seen. Vast numbers of this *Nerine* occur in moist depressions, making magnificent and unforgettable massed displays when in flower in April. The large flowers are distinct with the upper tepals arranged vertically in a fan shape. It tends to be almost evergreen, the leaves occurring with the flower. The seeds are more rectangular than round. Because its marshy high altitude habitat is difficult to simulate, it does not adapt easily to cultivation.

There are three species of broad-leaved nerines in the Eastern Cape. *Nerine alta* grows in full sun in damp marshy areas in the Kei Road, Stutterheim and Cathcart districts. The tepals are very fine, tending to roll into tubes that are strongly crisped giving the impression of a dainty, spidery flower. It is dark pink in color, deciduous and flowers in late April and May. *Nerine undulata* occurs further west in the Adelaide and Bedford districts. While the leaves are similar, it is remarkably different from *N. alta* in the flower and tepal shape. Tepals are broad and shorter (stubby) with strongly crisped margins - much paler pink than *N. alta*. It flowers in May. It grows naturally near shady forest margins. It is virtually evergreen, with leaves dying back briefly at flowering time but emerging soon after. In contrast to *N. alta*, bulbs multiply profusely. This is a very showy, hardy and robust species that is very easy and rewarding to grow. The third broad-leaved species is *N. flexuosa* from the southern aspect and summit of the Bosberg near Somerset East, where it occurs in well drained peaty soil on

steep slopes in fairly thick fynbos type vegetation. It is the last nerine to flower, in late May and June. It is almost evergreen with leaves broad, flat and long. Flowers are large, almost as big as *N. bowdenii*, but with shorter tepals and a pale pink color.

In a category of its own is *N. huttoniae*, found in alluvial sandy soil on the banks of the Fish River. In appearance it is much like a *Brunsvigia* with a very large inflorescence and up to eight broad strap-like leaves which occur at the same time as the flowers in early March (Dold and Weeks, 2000).

HAEMANTHUS

At least five species of this fascinating genus with many varieties occur in the East Cape. The most widespread is *H. albiflos* (Fig. 13), which is amazingly adaptive and versatile in its habitat. It is a particularly desirable and easy to grow garden subject and is also suitable as a ground cover in areas of semi-shade. It is equally at home in deep shade on forest floors, on rocky sea shores exposed to salt spray, in coastal dune forest, on cliff faces in hot river valleys where it clings in large clumps to crevasses in full sun, and in shady places on high altitude inland mountain ranges. It is evergreen and multiplies vegetatively, as well as from seed. The attractive white flowers appear in May and the ripe seeds are carried in equally attractive clusters of scarlet fruit. An interesting dwarf form with oval leaves occurs as single individual plants on bush clad hillsides in the Keiskamma River valley.

Haemanthus montanus and *H. humilis* are much more localised in their distribution. *H. montanus* prefers small areas of poorly drained shallow soil with an impervious substratum. It completes its annual cycle in four months, the period during which its fairly hostile habitat remains moist. It occurs in dense stands, the large cream flowers appearing in early January, rapidly followed by two or three upright leaves. The seeds ripen by mid February and germinate rapidly around the parent plants. The leaves dry off and blow away by the end of May when all signs of the bulb population have vanished. It adapts well to gardens and containers, and despite its long dormancy, is an attractive subject. *H. humilis* var. *humilis* has fairly round flat leaves and occurs in isolated colonies on steep slopes between protective rocks. It is extremely variable with regard to size, the degree of hairiness and the color of leaves and flowers. For instance, a colony in the Kei River Valley growing under acacia trees in semi shade has small grey hairy leaves and cream flowers, while another colony, growing in full shade on a south facing cliff less than 10km distant, has massive dark green leaves as large as dinner

plates, almost hairless, and gorgeous large deep pink flowers. The rare *H. carneus* is very closely related to *H. humilis*, the differences being a rather looser, widely spreading umbel and stamens included well within the perianth, the only known *Haemanthus* with this feature. It occurs in grassland on the Bosberg mountain near Somerset East.

Alas, the future of the floral riches of the Eastern Cape is bleak. Many factors have led to the rapid degradation of the pristine ecosystems described by early travellers and botanists who visited this region a century and more ago. Commercial farming, overgrazing by domestic cattle, sheep and goats, particularly on communal land, commercial forestation and the introduction of alien vegetation have all contributed to a rapid decline. The ever increasing harvesting of wild medicinal bulbs for traditional herbal remedies has now become gross over-exploitation for commercial purposes. However, small areas have remained protected. For instance, the road and railway reserves throughout the province are areas where some bulbs still survive. Small areas of natural vegetation within fences erected around arable croplands still preserve certain species. Limited areas inaccessible to both man and domestic animals do still exist. Sadly, even in these preserved areas, recent developments of a socio-political nature have led to dramatic declines in plant populations, and many rare species may become extinct. Measures to improve the conservation and status of threatened populations are imperative, but in the current socio-political climate, are unlikely to be put in place. It is therefore important that the most threatened species be identified, grown and multiplied in cultivation to preserve biodiversity before they are lost forever.

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FLOWERING OF PLANTS IN THE *BRODIAEA* COMPLEX

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The *Brodiaea* complex consists of approximately 40 known species (Schmidt, 1980), all of which occur naturally to the west of the Sierra Nevada (Niehaus, 1971). Archibald Menzies discovered the group in 1792 as new cormous wildflowers (now named *Brodiaea grandiflora* Sm. and *B. congesta* Sm.) growing in "New Georgia" on the west coast of North America (Smith, 1811). Menzies gave the specimens to two well-known taxonomists of that time, Salisbury and Smith. In 1808, the first description of any member of the genera, now termed the *Brodiaea* complex, appeared in Salisbury's proposal for the genus *Hookera* Salisb. (Salisbury, 1808). Unknown to Salisbury, Smith had used *Hookeria* previously to designate a genus of moss. That same year, Smith proposed the name *Brodiaea*, after J.J. Brodie, a Scotch cryptogamist, and the name was officially published in the Transactions of the Royal Horticulture Society in 1811 (Smith, 1811). A bitter controversy between the two taxonomists continued and the problem was eventually resolved in 1906 at the second International Botanical Congress, where *Brodiaea* was conserved over *Hookera* (Niehaus, 1971). The perplexity over the generic name for plants in the *Brodiaea* complex continues and has led to the publication of many different scientific names, often for the same species, including some with no botanical standing (Liberty Hyde Bailey Hortorium, 1976).

Presently, most taxonomists include 3 genera in the *Brodiaea* complex: *Brodiaea*, *Dichelostemma*, and *Triteleia* (Wilkins and Halevy, 1985). Keator (1987) summarized the distinguishing characteristics as follows: "*Dichelostemma* has flexuous flowering scapes, dense clusters of flowers, usually three fertile stamens backed by showy appendages, and a three-lobed stigma; *Triteleia* has straight scapes, open umbels of flowers, six fertile stamens occasionally backed by small appendages, and a barely lobed stigma; and *Brodiaea* has straight scapes, open umbels of waxy flowers, three fertile stamens (occasionally with appendages) that alternate with three differently shaped sterile stamens, and three-lobed stigmas with the lobes running down the style as wings". It is, however, not uncommon to use the genus name *Brodiaea* as the common or genus name for all plants in the *Brodiaea* complex.

The most comprehensive biosystematic study of the group was published by Niehaus in 1971. In that study, the differences between the three genera in corm-coat color, leaf surface, stomata, guard cells, perianth base, stamen number, anthers, staminodia, ovary attachment, stigma, seed surface, chromosome base number, and the natural habitat were described in great detail. Based on the information, Niehaus developed a phylogenetic scheme for 18 species in the *Brodiaea* complex. In recent years, characteristics other than the gross morphology, were used in delimitation of plants in the *Brodiaea* complex. In one study, the embryological characteristics during development of ovule, embryo sac, and endosperm were used to determine the taxonomic relationship between the three genera (Berg, 1996). Despite great differences in gross morphology between species within a genus, embryogenesis is very uniform within *Dichelostemma* indicating that embryology can contribute toward the clarification of taxonomic problems. Embryological similarities between the genera led the author to conclude that *Dichelostemma* is taxonomically close to *Brodiaea* but quite distant from *Triteleia*. In addition, the author proposed that *D. capitatus*, which was embryologically different from all other species in *Dichelostemma*, should be treated as a separate genus, *Dipterostemon*, first proposed by Rydberg (1912). The current trend in the use of a molecular systemic approach for taxonomical studies should elucidate the complexity over the phylogenetic relationship between plants in the *Brodiaea* complex.

In addition to the controversy over the generic name, there has also been considerable debate as to the family in which members of the *Brodiaea* complex should be placed. Some botanists have placed the *Brodiaea* complex in the Liliaceae family based on the ovary position (Liberty Hyde Bailey Hortorium, 1914; Lenz, 1975), whereas others assigned it to the Amaryllidaceae based on the umbellate inflorescence (Hutchison, 1959). Still others assigned them to the family Alliaceae, subfamily Allioideae, tribe Brodiaeeae (Berg, 1996; Traub, 1963). In recent years, analysis of the genetic, morphological, anatomical and biochemical characters of 52 closely related species in 10 families have demonstrated distinct differences between *Brodiaea* and those in the Alliaceae and have determined that they are more closely related to Hyacinthaceae (Fay and Chase, 1996). The authors thus proposed the family, Themidaceae, originally erected by Salisbury, for the tribe Brodiaeeae.

Flowers in the complex are variable. In some, the segments recurve sharply to form a star shape, while in others they expand into an open, bell-shaped flower. There are also differences in the inflorescence with some

being tight heads and others loose or open umbels (Fig. 1). They present a kaleidoscope of colors, ranging from white and yellow through pink, red, purple and blue. Currently, a few species are commercially produced in the Netherlands (International Flower Bulb Centre, 1993), with *Triteleia laxa* Benth. 'Queen Fabiola' or 'Koningin Fabiola' being the most widely produced for cut flowers.

All species in the *Brodiaea* complex form a replacement corm every year. Depending on the species and size of the mother corm, some form a variable number of cormels (Han, 1988). In a study by Han et al. (1994), corms lifted from the field in the summer remained dormant for a few months, then begin to grow in early fall, even if held dry at room temperature. Shoots began to emerge from the soil and root growth commenced two weeks after planting corms that had broken dormancy. The shoot axis consisted of two to five leaf primordia (depending on species), a vegetative meristem, and a leaf sheath. Floral induction, as indicated by the initiation of the bracts on the flanks of the meristem, occurred one month after planting the corms. Concurrently, the apical meristem for next year's corm originated near the apex of the mother corm and growth of the replacement corm began. Bracts continued to initiate followed by the formation of numerous flower primordia at various stages of development. In California, the first flower reached anthesis approximately 4 months after its initiation at which point the daughter corm had accumulated 80% of its final weight. The daughter corm continued to grow for approximately 4 more weeks until the leaves were completely senesced. It is interesting to note that the weight of the daughter corm was not affected by the removal of the devel-

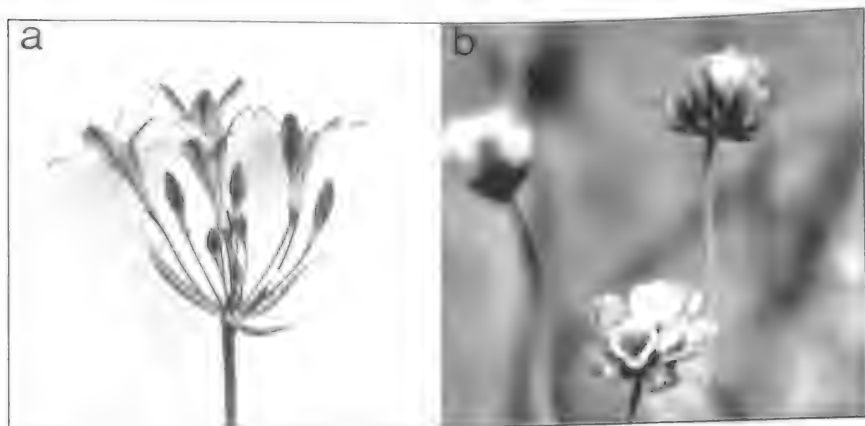


Fig. 1. Members of the *Brodiaea* complex (a) *Triteleia laxa* 'Queen Fabiola' and (b) *Dichelostemma pulchellum* Salisb. Photos by S. Han.

opening inflorescence in *T. laxa*, suggesting that there was little competition for assimilates between the two organs. Commercially, flowers are harvested when color is visible on 5 to 6 florets on the scape.

Plants are reproduced vegetatively and sexually. Depending on the species and the size of the mother corm, a variable number of cormels form in addition to the replacement corm. Though self-incompatible (Niehaus, 1971), brodiaea set seed easily via cross pollination. For maximum germination, imbibed seeds should be exposed to a minimum of 8 weeks of low temperature (3 to 5°C) for *T. laxa* (Han, 1993), *T. bridgseii*, and *T. ixiodes* (Han, unpublished data). Soaking *T. laxa* seeds in a solution of ethephon at 1000 mg·L⁻¹ for 20 h increased germination of partially stratified seeds (Han, 1993). Seedlings grown under short-day conditions produced cormels that weighed twice as much as those grown under long days. Three or four growing seasons are required to produce commercial-sized bulbs.

Most of the information on the cultivation of members of the *Brodiaea* complex is from studies conducted on *T. laxa*. For this, it has been determined that, after harvesting, corms should be held at 20°C until planting (Han and Halevy, 1993). Storage of corms at 2°C for 2 months hastened flowering by 3 to 5 weeks (Halevy, unpublished data). Typically, commercial-sized corms (> 5 cm in circumference, weighing >2.5 g) are planted in the fall in well-drained medium supplemented with fertilizer (Han and Halevy, 1993), although greenhouse studies indicate that corms weighing 1.1 g or more will all flower. Each corm will produce an inflorescence with 15 to 35 flowers. An exposure to 5°C cold temperatures for 5 to 12 weeks after planting significantly hastened flowering by approximately 70 days without affecting the quality of the inflorescence (Han et al., 1991). Long days (provided as night interruption or as day extension) hastened flowering as well but also reduced the number of flowers per

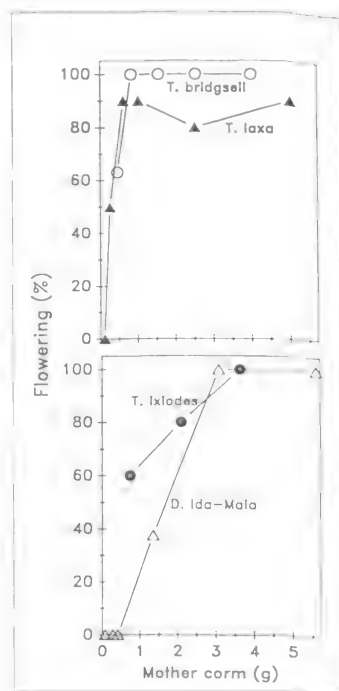


Fig. 2. Effects of mother corm size on percentage flowering of (top) *Triteleia laxa* and *T. bridgseii* and (bottom) *T. ixiodes* and *Dichelostemma ida-maia*.

inflorescence as well as the percentage of flowering. The number of flowers per inflorescence is correlated with the size of the mother corm. The larger the corm, the more flowers per inflorescence. Scape length, an important criterion for cut flowers, is not affected by size of the mother corm, low temperature treatment after planting, or daylength during forcing. Scape length, however, is significantly longer when plants are grown at low-night temperatures, perhaps due to the greater differences between day and night temperature (DIF). The marked increase in scape length from the low night-temperature treatment is not accompanied by a reduction in the quality of the inflorescence suggesting that low-night temperature should be used commercially to promote scape elongation in *T. laxa* 'Queen Fabiola'.

In addition to *T. laxa*, several species in the *Brodiaea* complex have been suggested as possibilities for use as cut flowers and garden plants (International Flower Bulb Centre, 1993). While, at present, there is no published information on the cultivation of species other than *T. laxa*, many

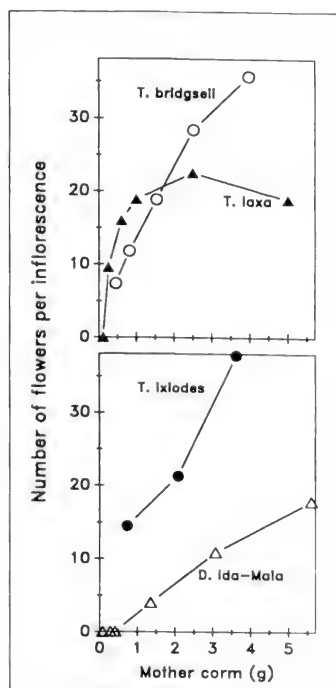


Fig. 3. Effects of mother corm size on the number of flowers per inflorescence of (top) *Triteleia laxa* and *T. bridgsell* and (bottom) *T. lxiodes* and *Dichelostemma ida-mala*.

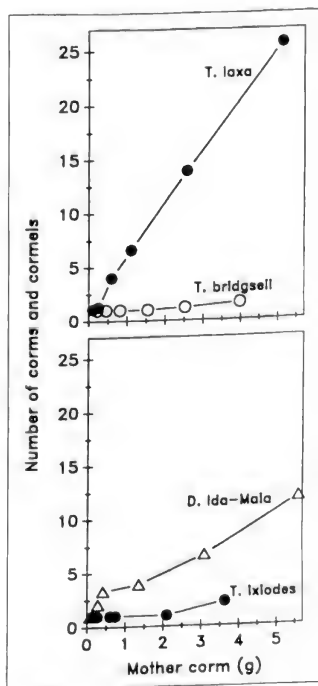


Fig. 4. Effects of mother corm size on the number of propagules (daughter corm and cormels) of (top) *Triteleia laxa* and *T. bridgsell* and (bottom) *T. lxiodes* and *Dichelostemma ida-mala*.

species have been successfully grown in an outdoor field in Davis, California using the same cultural techniques, suggesting that the cultural requirements of different species are similar. From a cultural point of view, the main differences between the various species of brodiaeas are the critical corm size required for flowering, the number of flowers per inflorescence, scape length, production time, and the number of cormels formed from each mother corm. In *T. laxa* and *T. bridgseii*, all corms weighing ~1 g will flower, whereas in *T. ixiodes* and *D. ida-maia*, a minimum corm size of approximately 3 g is required for 100% flowering (Fig. 2). In all species, the number of flowers per inflorescence, an indication of the quality of cut stems, correlates with the size of the mother corm (Fig. 3) whereas the length of the scape is not affected by the mother corm size. Scape length, however, varies greatly between different species and is ~20 cm, ~25 cm, ~30 cm and ~40 cm for *T. ixiodes*, *T. laxa*, *T. bridgseii*, and *D. ida-maia*, respectively. The number of days to flowering also varies between these species. In a study conducted in an outdoor field in Davis, California, corms of *T. ixiodes*, *T. bridgseii*, and *D. ida-maia* planted in November bloomed in April of the following spring whereas those of *T. laxa* bloomed 5 to 6 weeks later in mid-May. The forcing time for these species is likely to differ when grown in the greenhouse. The number of cormels formed varies significantly between species. *T. laxa* and *D. ida-maia* formed clusters of propagules around the daughter corm and the number of cormels increased as the size of the mother corms enlarged (Fig. 4). The author counted up to 101 cormels formed from one large *T. laxa* mother corm. *T. bridgseii* and *T. ixiodes*, on the other hand, typically formed a replacement corm (Fig. 4) with occasional formation of one additional cormel. Commercial corm production of the latter species would require other means of propagation, i.e. seeds or tissue culture. Most *T. laxa* produced one flowering scape per corm, whereas two flowering scapes per corm was detected in *T. bridgseii* and *D. ida-maia* when the mother corm weighed > 4 g.

Most of the plants in the *Brodiaea* complex can be easily cultivated and are considered to be among the most versatile California native bulbs for the garden (Keator, 1987). Various species have been cultivated in England (Hoover, 1939). In nature, each species exists on one or a few soil types (Niehaus, 1971), all of which were characterized as gravelly clay with or without a hardpan, clay-loam developed from basic igneous rocks, or clays derived from serpentine rock. However, they can be grown in any soil except those that are very wet or heavily manured (Bailey, 1914). Most species are found in areas

that are wet in the winter and dry in the summer (Keator, 1987) and in sunny fields that are semi dry (Schmidt, 1980). A few species grow in meadows (Keator, 1987; Schmidt, 1980). For cultivation, a well-drained, organically amended soil is preferred (Wilkins and Halevy, 1985). *T. laxa*, the most widely cultivated species, is injured at temperatures below -5°C (De Hertogh, 1996). It is reliably hardy in areas with minimum temperatures between -1 and -6°C and apparently naturalizes in areas with minimum temperatures dropping to between -18 and -23°C (De Hertogh, 1996). If adequately mulched, *T. laxa* can be grown as annuals in areas with minimum temperatures between -23 and -29°C . It is likely that regions with a Mediterranean-type climate would encourage the naturalization of this species.

In conclusion, many of the 40 species in the *Brodiaea* complex have beautiful flowers that have potential for commercial production. They are also reported to be exceedingly variable and commonly polyploidy (Niehaus, 1971). The extent to which they have been used as cut flowers may have been restricted, in part, by the limited supply of corms offered by nurseries. The ease at which brodiaea corms can be produced by seed propagation provides a means for mass production for commercial usage.

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***SIPHONOCHILUS AETHIOPICUS* (ZINGIBERACEAE), THE PRIZED
INDUNGULU OF THE ZULU—AN OVERVIEW**

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See page 88 for color plates.

INTRODUCTION

The Zingiberaceae is quite a large family with some 1300 species, centered chiefly in Indomalasia. Sub-Saharan Africa is modestly endowed with approximately 100 ginger taxa in four genera, yet at its southern tip only a single species is indigenous, *Siphonochilus aethiopicus* (Schweinf.) B.L.Burt (tribe Hedychieae). Until recently it was unclear whether only a single species of *Siphonochilus* occurred within the *Flora of Southern Africa* (FSA) region. This uncertainty may be loosely attributed to the inconsistent polygamous production of hermaphroditic and female flowers by this taxon (evidently on the same rhizome; Wood and Franks, 1911), and is reflected in a variety of synonyms. These have been listed in the most recent taxonomic treatment (Smith, 1998) as *Cienkowskia aethiopica* Schweinf., *Kaempferia aethiopica* (Schweinf.) Benth., *K. ethelae* J.M.Wood, *K. natalensis* Schlecht. and K.Schum) J.M.Wood and Franks, and *Cienkowskiella aethiopica* (Schweinf.) Y. K.Yam. The species is widespread in Africa, extending from the Eastern Cape in South Africa north to Ethiopia and equatorial West Africa, and further west to Gambia (Smith, 1998). Smith recorded *S. aethiopicus* (Wild Ginger) as a highly polymorphic species, with the color, size and depth of lobing of the labellum varying within single populations. Even the size of the conical rhizomes and elongate tubers varies considerably. Plants are herbs with false stems up to 60 cm tall, and thickened aromatic rhizomes to which numerous tubers are attached. The leaves are radical, long, and tapering. The bisexual flowers are particularly showy; both these and the female flowers are produced at ground level directly from the rhizomes and are colored white, yellow and mauve (Figs. 1-2; Smith, 1966). For a full species description and scientific illustration readers are referred to Smith (1998).

This contribution seeks to highlight the plight of an important and over-exploited ethnomedicinal geophyte from South Africa, while also revealing what is more generally known of this potential commercial crop.

Biosystematic, horticultural, ecological, conservation, ethnobotanical, phytochemical and pharmacological reports are overviewed, revealing, *inter alia*, a partial success story in conservation through cultivation.

CONSERVATION STATUS AND DISTRIBUTION

In South Africa, *S. aethiopicus* is in danger of extinction following a reduction of numbers of individuals to a critical level (Hilton-Taylor, 1996), despite being afforded legal protection (Scott-Shaw, 1999). This follows prolonged over-exploitation for the medicinal plant trade (Burt Davy, 1910; Mander, 1998). By 1915 Wood was confident to report that this geophyte had been almost extirpated from Natal. Prior to this, in the late 1870's, Wood had found *Siphonochilus* growing at Inanda near Durban. So abundant was this valued medicinal plant that *circa* 1900 the Basuto reportedly carried off pack horse-loads of the Inanda rhizomes to their mountain kingdom (Wood and Franks, 1911). It is believed that just such unsustainable utilization has led to its complete disappearance from the natural flora of the province of KwaZulu-Natal (KZN) (Gordon-Gray et al., 1989; Scott-Shaw, 1999), where it has not been found growing in the wild for over 80 years. However, specimens may still occasionally be observed in the gardens of traditional medical practitioners (Crouch and Hutchings, 1999). Such cultivation practices, locally in evidence from the 1880's (Wood and Franks, 1911), have fueled doubts over its natural occurrence in the extreme south of its range (Williams et al., 1996). Within KZN, *S. aethiopicus* has historically been known from the Umhloti (Wood and Franks, 1911), Riet (Wright, 1913) and Umtwalume (Burt, 1982) Valleys, Inanda, Ongoye (Wood, 1911), Hlophenkulu (Gerstner, 1938), Dumisa and Umbambasa (Scott-Shaw, 1999). A report on its present occurrence at Lusikisiki in Pondoland, Eastern Cape (Scott-Shaw, 1999) may relate to the recorded trade of Wild Ginger to that region from Inanda in about 1880 (Wood and Franks, 1911). The taxon is not considered to be as threatened with extinction at a global level (Status I; Walter and Gillett, 1998) for, despite its plight in South Africa, it is widely distributed in savannah regions of its tropical African range. However, Scott-Shaw (1999) reports on critically low numbers in most of these territories. Protection of the last genetic reservoirs in southern Africa is unfortunately inadequate, for 65% of the remaining sites

are outside of established reserve or conservation areas, and remain vulnerable to exploitation. Such is their popularity that three of the six populations 'protected' within reserves are still being heavily exploited. A total of 39 populations could be traced, with 44% of them extant, 7% of unconfirmed status, and 49% believed to be extinct. The Mpumalanga Parks Board (incorporating the Threatened Plants Unit, Flora Sub-Section of the Transvaal Provincial Administration) has monitored the status of nine of these remaining populations and observed a 64% decline in numbers of individuals over the course of just four years. This finding confirmed earlier depredation observations made by Onderstall (1978). Based on 1993 and 1999 census data it is calculated that 5214 plants are known to exist in the wild. The Red Data List assessment (IUCN, 1994) of *S. aethiopicus* for South Africa is accordingly determined to be Critically Endangered (CR A1b,c,d,e). Figure 3 shows the current as well as historical distribution of this species, based on PRECIS records and other documentation.

ETHNOBOTANY IN SOUTHERN AFRICA

The Zulu know this *muthi* (ethnomedicinal) subject as *indungulu* (Wood and Franks, 1911; Gerstner, 1938), *isiphephetho* (Cunningham, 1988) or *ithole* (Williams et al., 1996) and employ the rhizome in a cough and cold remedy, in tonics, and in treating hysteria (Wood and Franks, 1911; Gerstner, 1938; Hutchings et al., 1996). A cold infusion of the rhizome is recorded to have been used by the Zulu and Sotho for horse-sickness (Wood

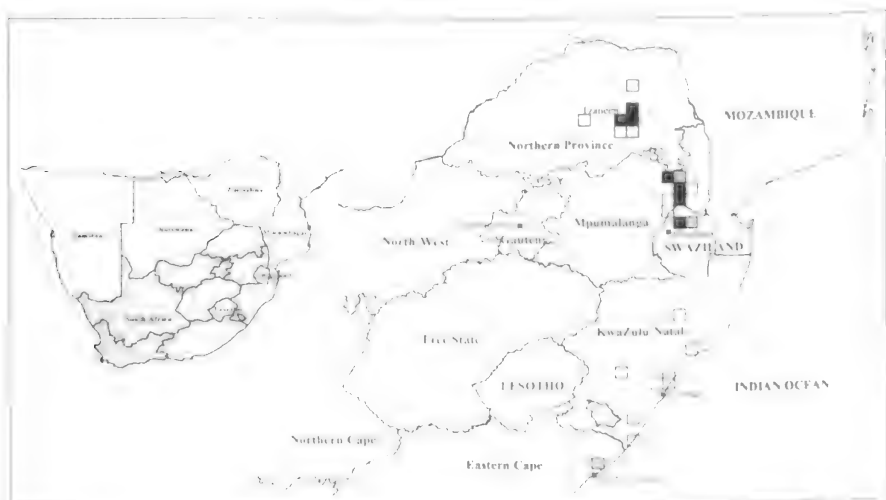


Fig. 3. The historical and current distribution of *S. aethiopicus* in southern Africa. Extant populations (■), unconfirmed (▨), extinct (□).

and Franks, 1911; Watt and Breyer-Brandwijk, 1962), although it has never been clear whether this was in a prophylactic or curative sense (Burt-Davy, 1910). The rhizome is also said to induce stupor in the horse (Watt, 1967). Watt and Breyer-Brandwijk (1962) further reported on its use by the Swazi as a malarial remedy and for the relief of menstrual pain, for which purpose the rhizomes were chewed. The Swazi know the plant as *isithungulu* or *sithungula*. Elsewhere in the region rhizomes have been employed in the treatment of rheumatism, toothache, neuralgia, (Watt and Breyer-Brandwijk, 1962), and to decongest nasal passages (Onderstall, 1978). In conjunction with *Alepidea amatymbica* (Apiaceae), a medication for abdominal cramps and colic is prepared (Felhaber, 1997). Herbalists report that plants protect them from the toxic effects of some of the plants they harvest (Williams et al., 1996). Plants are also grown as protective charms about Zulu homesteads based on the belief that they confer protection against lightning (Burt, 1982) and snakes (Wood and Franks, 1911). Evil spirits too may be warded off, the Xhosa of Idutywa (Eastern Cape) employing the powdered roots of *isiphephetho* to this effect (Johnson, 1985). It is both ironic and significant that the cultivation of Wild Ginger (Van Warmelo, 1963) for its magical properties (Fig. 4) has served to conserve something of the remaining genetic diversity, albeit *ex situ*. A seasonal usage character is in evidence. Webb and Wright (1979) recorded that historically the plant was used in summer by the Zulu to ward off lightning (presumably as a cultivated charm), and taken in winter to treat fevers. Oddly, this magical plant is considered to precipitate crop failure for those who dare cross their garden while holding it (Webb and Wright, 1979), and to attract lightning to those who chance harvesting it during its active growing state (Williams et al., 1996).

Siphonochilus aethiopicus is one of the first South African medicinal plants to have been recorded in trade (Wood, 1896; Webb and Wright, 1979). Burt-Davy (1910) described the traffic in dried rhizomes from what is today Mpumalanga to Gauteng (Fig. 3), a trade still in evidence although plants are reputedly scarce and in short supply (Williams, 1996). Likewise, Wood and Franks (1911) reported on the export of material from Inanda near Durban to the Eastern Cape, and to what is today the neighbouring country of Lesotho. An international trade in *Siphonochilus* continues to the present (Marshall, 1998) to supply plants of what rates as one of the ten most popular items in the Durban *muthi* markets (Mander, 1998), this out of some 450 species in local commerce. In a parallel study (Mander, 1997),

ranked *Siphonochilus* alongside *Alepidea amatymbica* as the most popular medicinal plant in the province of Mpumalanga. In this region it is known as *stungul* (Onderstall, 1975), *xirungulu* and *spepetho* (Mander, 1997), *sithungula* (Swazi), *sherakula* (Tsonga), and historically as *sherungulu* (Burt Davy, 1910). In the Northern Province the Sepedi (North Sotho) call it *serokolo*, while Afrikaans speakers label it *Wilde Kanna*. Wild Ginger material traded in Mpumalanga is reported to be sourced locally (Mander, 1997), whereas this is not the case for rhizomes sold in the Durban *muthi* markets. Rhizomes originate in Swaziland (Cunningham, 1990), the Transvaal (likely the Mpumalanga and Northern provinces; Cunningham, 1988) and Mozambique. This demand has impacted significantly on Swaziland's rare and localised stocks (Compton, 1976; Fig. 3), leading to voiced concerns (Marshall, 1998). The increasing scarcity of rhizome material has been reflected in the near tripling of Wild Ginger's retail value during the 1970's (Cunningham, 1988). However, much of the material appearing in Durban (Fig. 5) is now grown on a small scale by rural farmers in the Eastern Cape, although it is rarely available and therefore highly priced (R5-R10 per rhizome). Oddly, it was found, in the course of field surveys, that in the Tzaneen district only the larger rhizome section from the previous season's growth was harvested. The rest of the rootstock is discarded. This selection process possibly relates to high concentrations of efficacious constituents in particular organs.

Elsewhere in Africa the rootstock is used in ethnomedicine, but additionally employed as a spice (Pammel, 1911; Dalziel, 1937; Williamson, 1975). In this regard it is reputed to have the sharp taste of real ginger (Smith, 1966; Onderstall, 1978).

USE BY ANIMALS

During 1989, at the sight of one *Siphonochilus* population in the Kruger National Park, evidence of elephant digging activity was recorded. A large trench was scored right through a population, a ranger noting that elephants travelled large distances to access the aromatic rhizomes. Interestingly, all three of the Kruger populations are situated below marula trees (*Sclerocarya birrea* subsp. *caffra*), a favourite fruit source for this herbivore. Could it be that elephants have played a role in the dispersal of *S. aethiopicus*? Given that seed-set is apparently poor for this species (Nichols, 1989), the dispersal of large vegetative propagules by mammals may be an important consideration.

CHEMISTRY AND PHARMACOLOGY

The analysis of *Siphonochilus* tubers by a Swiss essential oil manufacturer some 90 years ago offered few insights to the chemistry of this species (Burt Davy, 1910). In fact, it would appear that the first definitive phytochemical accounts of *S. aethiopicus* appeared in early bulletins of the Imperial Institute. Steam distillation of the dried rootstocks reportedly yielded 2% of a pale yellow volatile oil (Dunstan, 1915; 1916). This product comprised a pleasant element scented of orange flower oil (93%), and a second heavier oil (7%) described as possessing the “less agreeable smell” of crushed ivy leaves. A new ketonic compound was later isolated together with terpenes (dipentene, pine, and sesquiterpenes), cineole, linalool, and esters (mainly methylantranilate; Goulding and Roberts, 1915). Caustic treatment of the oil much improved its odour. Terpenoid constituents (especially the sesquiterpenes) accounted for nearly 50% of the oil components. A further consignment of rhizomes (235 lb!) was dispatched to the Imperial Institute in August 1915, the oil extracted (yield 1.8%), and commercially evaluated by a large number of manufacturing perfumers, toilet soap manufacturers, and dealers in perfumery products (Anonymous, 1916). All concerned felt that the oil would not be of much value, being not especially attractive to the nose, and possessing insufficient amounts of constituents of worth to the perfumery industry. When tested by a soapmaker as a perfume substitute for spike lavender oil, the *Siphonochilus* oil was found less permanent and tended to darken the soap on keeping. It was deemed that the pleasant scented methylantranilate and linalool elements were masked by the more abundant and much less agreeable aromas of cineole and the ketone (Anonymous, 1916).

The terpenoids may be responsible for the reported beneficial effects of Wild Ginger in the treatment of colds and flu, for, like many other volatile oils, these should have a decongestant and antiseptic action. Further research is required. Of interest is the pharmacological report of McGaw et al. (1997) in which the authors tested a number of Zulu medicinal plants used in the treatment of pain and inflammation. In an assay which considered the ability of materials to disrupt the inflammation process, ethanolic extracts of *S. aethiopicus* leaves were found to exhibit higher inhibitory activity than indomethacin (0.5 µg), a standard pharmaceutical drug used as an anti-inflammatory. One wonders how much more active rhizome extracts would be, given that these organs are the parts used in traditional

medicine. What these findings indicate though is that leaves could possibly be substituted for rhizomes, so allowing for less destructive (sustainable) harvesting of limited materials. This *in vitro* anti-inflammatory activity validates the traditional use of plants by the Zulu in treating pain and body swellings (Pujol, 1993), and the Swazi in treating dysmenorrhoea (Watt and Breyer-Brandwijk, 1962).

HABITAT AND ECOLOGY

In the northern provinces of South Africa, *Siphonochilus aethiopicus* occurs in Lowveld Sour Bushveld (9) veld type (Acocks, 1988), within Tall Open or Closed Woodland (Edwards, 1983). Some populations are situated on the transition zone between Acocks' Sour Lowveld Bushveld (9), and Lowveld (10) veld types. To the north in tropical East Africa, this species similarly occurs in deciduous woodland, wooded grassland and bushland (Lock, 1985). For the province of Mpumalanga, satellite images show that only 54% of the Lowveld Sour Bushveld is still considered to be in a natural state, with 4% of it degraded and 42% of it wholly transformed. The commercial forestry industry has had the greatest impact on the Lowveld Sour Bushveld with 33.4% of this veld type under exotic timber plantations by 1995. Accordingly, existing and potential habitat for *Siphonochilus aethiopicus* has been considerably reduced through commercial developments. Further habitat transformation is likely given the suitability of such areas for agriculture. However the influence of habitat destruction on the conservation status of Wild Ginger is relatively small compared to the threat of ongoing harvesting for the *muthi* trade. In habitat, plants typically occur in a well-drained humus-rich granitic loam, often close to drainage lines. Populations of up to 4000 plants have been recorded, although most extant sites (60%) today hold fewer than 100 individuals.

The following associated plant species are characteristic of areas in which *S. aethiopicus* grows, in descending order of occurrence for each life form category: trees (all listed being winter-deciduous): *Pterocarpus angolensis*, *P. rotundifolius*, *Heteropyxis natalensis*, *Dombeya rotundifolia*, *Peltophorum africanum*, *Combretum zeyheri*, *Ziziphus mucronata*, *Acacia caffra*, *Bridelia mollis*, *Terminalia sericea*, *Pseudolachnostylis maprouneifolia*, *Berchemia zeyheri*; shrubs: *Bauhinia galpinii*, *Rhoicissus tridentata*, *Dichrostachys cinerea*, *Pouzolzia mixta*, *Euclea natalensis*; and grasses and forbs: *Panicum maximum*, *Setaria nigristrostris*, *Themeda triandra*, *Oxalis obliquifolia* and *Commelina benghalensis*.

FLORAL BIOLOGY

Despite Wood and Franks (1911) reporting that plants are polygamous (producing both female and hermaphroditic flowers on the same rhizome, albeit at different times), monitoring of six *Siphonochilus* genotypes under cultivated and semi-cultivated conditions failed to confirm this early observation (Burt, 1982; Gordon-Gray et al., 1989). However, two horticulturists have recently observed polygamy in plants grown, as were Wood and Frank's, in the subtropical Durban region (M. Gillmer and R. Symmonds, pers. comm.). Flowering in *Siphonochilus* appears a temperamental affair, a number of growers reporting failure to successfully flower their specimens over several successive years (Onderstall, 1978; Burt, 1982). In the wild, plants grow in deciduous woodlands such that during the dormant phase (June-October) the soil above the perennating organs (up to 15 cm in depth) will be exposed and thus significantly warmed by the winter sun. This may positively impact on the initiation of the (summer) flowering process, the setting period for which was reported by Gordon-Gray et al. (1989) to be during this resting season. Once budding of inflorescences has been initiated, even the transplantation of rhizomes will not cause the flowering process to abort, and, in fact, is reported to stimulate it (Onderstall, 1978; Gordon-Gray et al., 1989). Flowers have a "*haunting, spicy fragrance...reminiscent of ginger*" (Onderstall, 1978), particularly evident in the early evening and late afternoon (Gordon-Gray et al., 1989). Up to 25 flowers may be sequentially produced by a plant over a single summer season (November-December). Nichols (1989) noted that the emerging leaves only continue to grow and expand once flowering is completed by mid-December; this ensures that the flowers are properly visible to the pollinators. Although witnessing (female) floral visitation by an unidentified "mucid fly" (rather generically illustrated by Millicent Franks at the Natal Herbarium!), Wood (1911) could later find no seed, the subterranean ovaries having rotted in the ground. Wood observed that the tube in the female flowers is very long and narrow, such that fertilization could only be effected by a minute insect. Small dipterids (2 mm in length) have more recently been observed attracted to flowers, but their role remains unclear, especially since self-pollination seems likely in bisexual flowers (Gordon-Gray et al., 1989). Female flowers have not been observed fruiting, suggesting that apomixis (seed production without fertilization) does not operate. When polygamy has been observed, the female flowers largely outnumber

the perfect ones (Wood, 1911). Flowers typically open during daylight hours and then for one, or at most two days (Wood and Franks, 1911; Onderstall, 1978; Gordon-Gray, 1989).

EARLY COMMERCIAL INTEREST

The aromatic rhizome of Wild Ginger, besides possessing an obvious cultural value to a myriad of ethnic groups in southern Africa, has excited early colonists looking to develop new products for the home countries. From both Natal and Transvaal rhizomes were sent to the Imperial Institute in London for analysis and consideration of their economic value. The "remarkable fragrance" of the rhizomes prompted this interest, suggesting an application in perfumery for the likes of scenting toothpowders (Burt Davy, 1910; Dunstan, 1916).

COMMERCIAL CULTIVATION OPPORTUNITIES

The horticultural potential of *S. aethiopicus* has long been recognised, Wood presenting it (as *Kaempferia ethelae*) to the British gardening community as early as 1898. Agricultural production to meet traditional market requirements has repeatedly been mooted (Cunningham, 1988; 1990; Gordon-Gray et al., 1989), leading to various horticultural and reproductive biology studies. Fortunately, in making the most of available market opportunities (and simultaneously addressing the local extinction threat), the conservation through cultivation of *S. aethiopicus* as a highly valued commodity has become a reality. Cunningham (1990) considered *Siphonochilus* to be exceptional amongst high conservation priority species in its suitability as a commercial cultivation prospect. Subsequent authors (Mander, 1998) have held to this view. Ironically, the commercial cultivation potential was much earlier recognised and exploited by the Zulu from at least the 1880's (Wood and Franks, 1911).

Unfortunately, the residual genetic diversity of Wild Ginger in South Africa (the genetic polymorphism) could present problems to growers of this emerging cash crop with respect to the selection and/or development of superior chemotypes, vigorous forms, and disease and drought-resistant cultivars. Although a large single population in the Tzaneen District has been shown by allozyme analysis to possess wide genetic variation (Makhuvha et al., 1997), few such large populations still exist, in contrast with historical accounts dating back to the early 20th century (Goulding and Roberts, 1915).

PROPAGATION

The most efficient way of propagating this species is by vegetative means (Nichols, 1989), given that the seeds develop and mature underground (January-February), and accordingly are difficult to find. Fruit-set is typically poor for this species, and, when occurring, the seeds germinate viviparously, the seedlings penetrating through the decaying fruit walls. These progeny are reportedly susceptible to damping-off (Gordon-Gray et al., 1989). Even when recovered and sown, seeds may take a year to germinate (Nichols, 1989). Propagation through either simple splitting of rhizomes in late winter (Williams et al., 1996), longitudinal sectioning of rhizomes (McCartan et al., 1999), or through tissue culture (De Lange et al., 1991) is recommended for bulking-up purposes.

TISSUE CULTURE

For the establishment of cultures, essentially the same procedure as used for micropropagating *Zingiber officinale* (De Lange et al., 1987) has been followed (De Lange et al., 1991). In the course of propagating from the rhizome bud explants (at the Endangered Plant Laboratory at Kirstenbosch), De Lange et al. (1991) experienced serious contamination in the initial phase. The explants needed to be re-sterilized once or twice, leading to shock which slowed initial growth. A multiplication medium with a relatively high cytokinin content was used, resulting in an approximately four-fold rate of shoot proliferation per one-month subculture period. Rooting of shoots was best initiated *in vitro*, on an auxin-containing medium. Prior to hardening-off under nursery conditions, plantlets were rinsed under running tap water to remove the agar medium (De Lange et al., 1991). They were then planted in clumps of four or five in punnets, with a planting mixture of bark and polystyrene (3:1), each clump being covered with an inverted bottle. Bottom heating was applied during winter. After one month the bottles were removed, but the plants were kept under intermittent mist for two weeks (De Lange et al., 1991).

CULTIVATION

Until recently little was known about the monocultural requirements of Wild Ginger. It was suggested that the information on commercial ginger in South Africa should be applied until further experience was gained (De Lange et al., 1991). As it turned out, a subsequent agronomic evaluation of the effect of propagule size, density and soil type on rhizome yield

(McCartan et al., 1999) revealed remarkably similar responses of these two species in cultivation. It would be logical to cultivate *Siphonochilus* in previously known Wild Ginger areas, co-incidentally the same region that commercial ginger is currently grown. These are the lower lying, warmer and more humid parts of the Mpumalanga Lowveld, and KZN's warm subtropical east coast (Nichols, 1989). This author suggested that the soil should be loose, friable and well drained. De Lange et al. (1991) recommended soils with a high water holding capacity. For optimal rhizome development De Lange et al. (1991) recommended that the topsoil be at least 250 mm deep. Nichols (1989) suggested that trenches be dug and filled with compost (as one would do when growing commercial ginger) to encourage good root growth. This would further ensure that larger, better-formed rhizomes are produced, with many new "eyes" to split off at the end of the growing season, for propagation purposes. Nichols (1989) found that plants responded well to high levels of organic matter in the form of sludge in the sandy, highly leached soils found in Durban. De Lange et al. (1991) suggested that the rhizome pieces should be planted on ridges, the most desirable planting time being late winter or early spring. In line with soil preparation for commercial ginger cultivation (Anderson et al., 1990), these authors recommended the application of 70 tons per hectare kraal manure or 24 tons per hectare chicken manure. The high feeding requirement of *Siphonochilus* was confirmed by McCartan et al. (1999) who reported a five-fold increase in rhizome yields per hectare when soils were compost-enriched. They further determined that a high density planting (444,444 plants per hectare, spaced 15 x 15 cm) was more profitable than a lower one (111,111 plants per hectare, spaced 30 x 30 cm). A maximum rhizome yield of 43.8 tons per hectare was obtained when using small (6.2 - 7.8 g) rhizome propagules rather than larger ones (12.6-16.4 g).

PESTS

Grasshoppers and other insects have been observed eating the leaves of wild plants in the northern provinces. In cultivation, Nichols (1989) noted that *S. aethiopicus* has never been observed afflicted by any pests or diseases. However, nematode and other infestations to which *Z. officinale* is prone (Anderson et al., 1990) need to be looked out for, as it is not known to what extent Wild Ginger is susceptible to such infestations. Significantly, in following the micropropagation protocol of De Lange et al. (1991) all original planting material would likely be nematode-free.

HARVEST

In southern Africa, the optimal harvesting period would be during winter (June), following the onset of dormancy. The rhizomes should be lifted and stored during winter and subdivided and planted in late winter or early spring (De Lange et al., 1991). Nichols (1989) advised that when splitting the rhizomes, not all tubers should be detached. He considered that these organs serve as water and nutrient reserves providing for flower and leaf production in the subsequent season. Security might be important considering its popularity and market value as an ethnomedicinal plant.

RESEARCH NEEDS, CONCLUSIONS

Despite its importance to a variety of southern and tropical African ethnic groups, our knowledge of *S. aethiopicus* remains lacking in several respects. Our understanding of its pollination biology, genetics, chemical diversity, flowering initiation, regulation of sexual expression and other autecological aspects would particularly benefit from further study. The ensuing findings could feed into management strategies devised to ensure the conservation of diversity in remaining populations of this critically endangered species. An optimised micropropagation protocol is yet to be formulated and published, in support of likely mass cultivation developments.

From a commercial viewpoint, the selection of cultivars exhibiting superior growth forms for amenity horticulture and superior chemotypes for possible phytomedicinal development is required. This begs the question: is this interest overdue or is it too late? Preservation through propagation may well have been achieved for the Wild Ginger, but what really has been conserved? The saga of *Siphonochilus* reveals only a partial success story. Given the limited wild stocks left in South Africa, and the implications this has for long-term crop development, it could be argued that too little was done too late. In hindsight, timely gene-banking would have been prudent. Perhaps this experience will ring as a noteworthy warning to parallel species recovery programs. Of the ten most popular *muthi* plants in local trade, three more are geophytes sliding inexorably through Red Data List ratings towards "Extinct in the Wild".

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A NEW SPECIES OF *CRINUM* (AMARYLLIDACEAE)
FROM MADAGASCAR

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See page 89 for color plates.

In November 1995, Dave Hardy from the National Botanic Institute in Pretoria and I departed on a flower-collecting expedition to Madagascar. On four previous occasions, Dave and I had pursued plant collecting in the field in Namibia, Botswana, and Zambia. It was an absolute pleasure to travel with Dave, for I considered him to be my teacher, guide, and friend. In addition to being a seasoned field collector and knowledgeable horticulturist, Dave was particularly infatuated with the local cultures and customs of the various countries he visited. Of all the countries in Southern Africa familiar to him, Madagascar was Dave's favorite place, and having visited this country more than 25 times, he was thoroughly immersed in the Malagasy culture.

Soon after our arrival in Antananarivo, Dave introduced me to a close personal friend, Alfred Razafindratsira, who was the proprietor of Madagascar Flora, a nursery specializing in indigenous Malagasy ornamental plants. Alfred, like Dave, had traveled extensively throughout Madagascar on botanical expeditions, and he was thoroughly familiar with the ecosystems and flora that occurred in his homeland. Upon learning of my interests in *Crinum*, Alfred displayed his *Crinum* collection, which included a small species that he had recently collected (not in flower) whose identity was uncertain. He presented me with three mature bulbs to take home. Thereupon, Dave and I embarked upon a 14-day cross-country adventure in a 4-wheel drive vehicle, during which time I began my study of Malagasy *Crinum*. Upon returning home to Texas, I cultivated Alfred's bulbs, and they bloomed during the (Texas) summer of 1996. The bulbs proved to be an undescribed species of subgenus *Crinum*.

Dave and I returned to Madagascar in late November 1996. On this occasion, Alfred took us on-site to one of three isolated locations known to him where the small, undescribed species occurred. The site was adjacent to the small village of Ambohimasimbola, approximately 19 km south of Antananarivo via a narrow winding dirt road. There had as yet been no summer rainfall in the region, and the landscape was brown. When we arrived at the site, I was immediately bewildered (Fig. 1). We were at the

summit of a barren granite hill, and never in my wildest expectations would I ever have searched for *Crinum* in such a habitat. The topsoil was extremely porous and shallow, being no more than 80-100mm deep; under no circumstances would it retain water, as beneath the topsoil lay solid granite. There was a sector where stonecutters had removed slabs of granite. The vegetation consisted mostly of wild grasses with a scattering of ground orchids. Alfred stated that the *Crinum* bulbs grew at the top and part way down the sides of the hill, but not at or near the bottom where the soil composition was different. After a lengthy search, we finally located a few bulbs with dried leaf stubble exposed at the soil surface. The bulbs grew just beneath the surface and were encased in thick tunics of dried leaf scales. We collected three bulbs with some difficulty owing to the coarse granite soil. An employee of Alfred's who accompanied us and who was quite familiar with the site, remarked that normally each bulb produced 1-2 scapes per season, each scape bearing umbels of 1-4 flowers.

In January 1998, Dave, Alfred, and I returned to Ambohimasimbola but with difficulty. The region had experienced a severe flood during the summer of 1997, and sections of the dirt road leading to the village had been washed away. Some repairs had been made to the road, but it was accessible only by 4-wheel drive. There had been some summer rainfall in 1998, and on this occasion we could easily identify bulbs in leaf (Fig. 2), although none had yet bloomed. We estimated that 250-300 bulbs resided at this location, and the site appeared to be safe from local habitat destruction, unless a commercial company undertook to exploit the granite deposits.

It is with a sad heart that I report the untimely death of Dave Hardy in May 1998, subsequent to complications arising from "routine" elective surgery. Following Dave's wishes, his ashes were scattered in the spiny forests of his beloved Madagascar.

***Crinum razafindratsiraea* Lehmiller, sp. nov. (subgenus *Crinum*).**

Species *C. firmifolium* affinis, sed statura parva et foliis marginatis denticulatis differt. Type: Madagascar. Near Ambohimasimbola, 19km south of Antananarivo. Ex Hort Lehmiller, from bulbs collected 30 November 1996, and cultivated in Southeast Texas, 1999, Lehmiller 1944 (Holotype: TAMU).

Bulb ovoid, 40-70 mm diameter, tapering to a short underground neck 20-30mm long, encased in thick tunics of brown leaf scales; basal offsets sometimes produced. Leaves 4-13, forming a rosette, suberect and arching, widest at the base and tapering to a slender point, deeply channeled but not

U-shaped, lacking a distinct midrib, margins denticulate, bearing closely spaced longitudinal nerves with cross striations visible with a magnifying glass, containing minute wooly fibers when torn apart, green, 60-88 cm long and 20-32 mm wide. Scape slender, compressed, reddish brown early but turning dull grayish green by anthesis, 52-60 cm long. Spathe with 2 bracts, the larger overlapping the smaller on both sides, becoming papery at anthesis. Umbel 1-9 flowered; flowers actinomorphic, sessile, opening at night, lightly scented. Buds slender and pointed, initially with distal rust red pigmentation fading to light green near anthesis, vertically drooping before arising to a near erect posture at anthesis. Perianth tube straight at anthesis, dull green, 80-120 mm long. Segments narrow and lanceolate, white ventrally, with a thin red dorsal keel, unequal with the outer segments longer and narrower, 68-96 mm long and 9-13 mm wide, apiculate, the outer segments bearing reddish green projections 4-5 mm long. Filaments six, spreading, white only at the throat, otherwise dark pinkish purple, unequal with those attached to the inner segments longer, 40-57 mm long; anthers black at maturity; pollen golden yellow. Style pinkish red, darker distally, 68-80 mm long; stigma capitate. Fruit globular with a short rostellum, 9-35 mm long, shiny green turning light golden yellow at maturity, 25-35 mm diameter, indehiscent; seeds 2-10 per fruit, smooth, partially angulated where compressed by adjacent seeds, light green, 10-20 mm diameter.

Habitat: Central Malagasy plateau; biphasic climate with summer rainy season and dry winter season. Confined to treeless rocky granite hills, occurring in shallow porous granite soils.

DISCUSSION

Herbert (1821, 1837) divided subgenus *Crinum* into two major subdivisions, "inclinatae" or buds inclined, and "nutantes" or buds nodding. This categorization was discarded when Baker (1888) adopted the scheme wherein the same subclass was segregated into subgenus *Stenaster* and subgenus *Platyaster*. Since current taxonomy only recognizes subgenus *Crinum* for the actinomorphic species, there may be merit in returning to Herbert's subdivisions. However, there are occasional exceptions (a possibility anticipated by Herbert). For example, Herbert correlated nodding buds with sessile flowers, to which *C. subcernuum* Baker of Southern Africa is a notable exception.

Herbert's budding phenomenon relates to the movement which buds traverse during the period just prior to anthesis. Buds which "nod" move from an erect position through a 180 degree arc to where they point directly at the ground on the morning prior to anthesis, only to rise to an erect/suberect position at anthesis that evening. The entire movement is accomplished in two days (Fig. 3 and Fig. 4). Buds which "incline," move from an erect state to an intermediate position, be it suberect, horizontal, or sometimes as far as 30-45 degrees below the horizontal, and then return to an erect/suberect posture at anthesis. A few species just "incline" to a suberect position as buds and then remain stationary while proceeding to anthesis.

There are only two Malagasy species of subgenus *Crinum* whose buds "nod" prior to anthesis, *C. firmifolium* Baker and *C. razafindratsiraea*. *C. firmifolium* is a huge bulb in comparison, bearing leaves up to 100 mm wide and umbels with as many as 27 flowers. Other contrasting features include: 1) leaves of *C. firmifolium* typically display coarse undulations, 2) leaf margins of *C. firmifolium* are entire and lack serrations/denticulations, and 3) flowers of *C. firmifolium* are subsessile and occasionally demonstrate petiole-like elongations to 10-20 mm.

Note: *Crinum firmifolium* is a distinct species from *C. ligulatum* Baker, the latter sporting an above ground leaf column, lanceolate leaves with a depressed midrib and lacking cross striations, sessile flowers, and inclining buds. The concept of *C. firmifolium* presented by Perrier (1939, 1950) should be disregarded as it incorporates six and possibly seven different species into a single taxon, and the treatment is laden with violations of the International Code of Botanical Nomenclature (Lehmiller, 1992).

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**NERINE REHMANII IN GAUTENG AND
MPUMALANGA, SOUTH AFRICA**

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See page 90 for color plates.

Nerine rehmanii (Figs. 1-3) is an elegant, dwarf, white-flowered species found on rocky hills and mountains in Mpumalanga and hills and ridges in Gauteng. The plants used to be well represented around Johannesburg but have dwindled a lot in recent times. Most of the available habitat has been destroyed through unprecedented suburban development as well as informal settlements that have become very numerous in the last five years.

In the less densely settled parts of Gauteng and Mpumalanga, the species is most abundant in short rocky grassland. The thin soil, over sheets of partly exposed rock, is ideal for the development of large groups of *N. rehmanii* bulbs. In these situations, grass tufts are usually sparse and the bulbs are protected by moss and clumps of *Selaginella*. The *N. rehmanii* colonies in different regions allow interesting comparisons and contrasts to be made as to factors which control the size of groups of plants and the recruitment of new individuals to the different populations.

Prior to the settlement of the two provinces by large numbers of humans, fire and grazing by various wild animals probably controlled the numbers of bulbs. Fire has the effect of burning off moribund vegetation and opening up new niches for seeds to germinate. The hooves of grazing animals often dislodge bulbs or damage them causing them to rot. Droughts also play their part. Intense heat dries out many of the bulbs in the shallowest soil.

In the modern environment, plant number is controlled in both some similar and also different ways. Droughts, fire, and heavy rainfall thereafter still control the contraction and expansion of *N. rehmanii* colonies. In addition, grazing by domestic livestock, reforestation with exotics and increased attack by the *Amaryllis* caterpillar play a significant role. These factors are discussed with examples drawn from field research conducted over the last decade.

NERINE REHMANII COLONIES AROUND JOHANNESBURG

Nerine rehmanii is found in healthy populations on the rocky ridges to the east of Johannesburg (Fig. 1). These ridges are too steep and rocky for housing developments and the habitat is virtually undisturbed by any form of

grazing. Fires occur at least once every two years, and, on some ridges, annually. Fire clears the habitat of moribund grass and allows the nerines to form dense groups where the grass cover is thin. Moss and *Selaginella* assist with the lodging of seeds when these are liberated at the end of the flowering period in late February and March. Most niches where the bulbs occur are so densely packed with flowering size bulbs that the only chance seeds have of germinating is during periods of heavy rainfall when they are dispersed more widely over the habitat. Exotic weeds and Kikuyu Grass invade the habitat in some areas, but this normally occurs where there has been some level of disturbance.

The Amaryllis caterpillar can be very destructive, eating flowers, seeds, stems, leaves and bulbs. Amaryllids, exotic and indigenous, are widely cultivated in Johannesburg and these function as an artificial reservoir for this pest, which may be very abundant particularly after mild winters.

***NERINE REHMANII* NEAR MORGENZON**

Morgenzon is a small farming town in the grassveld of Mpumalanga. There is a large population of *Nerine rehmanii* on a tall hill to the south west of the town. The farm is stocked with sheep and cattle and wild antelope are still found here in small numbers.

Nerine rehmanii is widely scattered in shallow soil over sheets of exposed rock, with some areas carrying dense clumps of short grass. The bulbs are found in dense numbers at the edges of the grass tufts and in niches under and around stones that litter the habitat. The more exposed areas with thin soil cover have few nerine bulbs as they are heavily trampled by livestock and antelope that graze on the grass swards growing on the rocks. There is practically no moss and *Selaginella* to protect germinating *N. rehmanii* seeds, and the trampled earth becomes very dry between rains. The grass swards form fire islands and are consequently full of moribund grass. This limits the potential for *N. rehmanii* to spread in these situations.

***NERINE REHMANII* NORTH OF BELFAST**

Belfast is in a cold, high rainfall part of Mpumalanga. *N. rehmanii* was once very common on rocky slopes to the north east of the town, growing in shallow soil on sheets of exposed rock. Most of these areas have been forested with exotics, particularly eucalyptus. The remaining habitat is very rarely burnt (except for narrow fire breaks) and hardly grazed at all by the few indigenous antelope that inhabit the area.

These populations have been static for several decades, occupying every available niche of limited habitat. The only time the habitat is cleared is when it is burnt after an exotic timber plantation is felled. This usually occurs just before another grove is planted.

The above discussion has indicated that a number of factors control *Nerine rehmanii* populations in habitats altered by man. The bulbs are capable of surviving in relatively degraded habitats and where there is an almost complete absence of the normal factors that permit contraction and expansion of the populations. Ironically, the most secure large populations are probably in suburban areas of towns and cities such as Johannesburg.

THE ECOLOGY OF *STRUMARIA GEMMATA* ON THE ANDRIESBERG IN THE NORTH EASTERN CAPE PROVINCE

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See page 90 for color plates.

Strumaria gemmata (Figs. 1-2) is a widely distributed species which occurs in both summer- and winter rainfall areas as well as regions which receive precipitation throughout the year. One of its most spectacular locations is the Andriesberg, north of Queenstown in the north-east Cape. A large population is to be found on this mountain and the observations that follow were made during the growing season of the last few months of the summer of the year 2000.

The Andriesberg lies in an area of relatively high summer rainfall. Temperatures on the mountain are mild in summer, but may get very cold in the winter months; well below freezing on occasion and with heavy snowfalls.

The summit of the mountain comprises a vast series of dolerite domes, on which a number of seasonal rivulets take their rise. The mountaintop is rich in lower-lying seepages with deep soil and a rich flora adapted to prolonged summer moisture.

Strumaria gemmata is found growing in pockets of shallow dolerite grit on the rocky domes, often on immense sheets of exposed rock. These situations are subject to extreme temperature variations, except for rainy periods in summer when cloud cover may last a few days or even weeks.

Strumaria gemmata grows from early November until the end of summer, generally entering dormancy with the first frosts of winter in late April and early May. The first substantial rains of summer are often delayed: they may fall at any time between October and late December. Superficial light rain is enough to initiate the growth cycle. The vast sheets of rock are large enough to serve as catchments for filtering negligible precipitation on to the soil pockets where *S.gemmata* grows. Bulbs here that receive some precipitation start to produce leaves at the beginning of November. In other groups of plants growing further away from the sheets of exposed rock, where more substantial rainfall is required to saturate the soil, leafing may only occur in December. Occasionally, bulbs which sprout in early November go dormant

if initial light rains are followed by scorching early summer heat.. They sprout again quickly once the rains resume.

In recent times colossal fires have occurred in the north-eastern Cape. Fires burn unchecked across many hectares of mountain grassland. Some farmers are no longer resident on their property and as a result fires burn unchecked across many adjacent farms. Much of the Andriesberg was burnt in such a fire in 1999. Evidence emerged that such large-scale fires have the effect of opening up areas for further colonization by *S. gemmata*. The species does not grow amongst dense grass or scrub here, but it does colonize grassy areas at the edges of sheets of exposed rock after burning and a good, thoroughly distributed seed set. Large scale fires, on a regular basis will probably improve the habitat for *S.gemmata* with a trend towards lighter population numbers owing to the greater carrying capacity of the habitat.

On the Andriesberg, *S. gemmata* flowers in late January and early February, well after the appearance of the leaves. Seeds are produced at the peak of the rainy season and are distributed by rainfall and wind. Dr Piet Vorster (Department of Botany, University of Stellenbosch, personal communication) reports that seeds are generally distributed by wind. The umbel with seeds detaches from the bulb and is blown around in the wind, distributing seeds in the process. Seeds ripen very quickly on the Andriesberg, particularly during dry spells when intense desiccating heat radiated from the rock shrivels the umbels and the seeds are shed. Dried umbels are later blown about in the wind in the manner described by Vorster, distributing the balance of the seeds. Seeds either germinate where they fall off the umbel, in situ, or else are washed over the rocky domes by rainfall, germinating if they find a suitable niche. Seed still on the umbels when they detach from the bulb are distributed by wind. The large populations of *S. gemmata* on the Andriesberg bear testimony to the success of these methods of seed distribution.

During dry summers most bulbs are likely to remain dormant. Flowering is good in years of average or above average rainfall. As a result, abundant seed production occurs in years when it has the best opportunity to germinate.

The Andriesberg lies almost entirely on Carnavon Estates, a private nature reserve. The mountain is well managed and not over-grazed. Different indigenous and exotic antelope species inhabit the mountain. They play a significant role in thinning the grass as well as loosening hardened soil in the rocky domes where *S. gemmata* seeds can lodge and germinate.

There is little doubt that the alteration of the fire regime on the Andriesberg will gradually change the ecology of the flora. Research opportunities of a most interesting and intricate nature can be expected to present themselves on the mountain in the early decades of this century.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Robin Halse, the owner of Carnavon Estates and his daughter Sarah for assistance with Landrover transport to the more remote and inaccessible areas of the Andriesberg. Thanks also to Dr. Piet Vorster of Stellenbosch University for sharing with us his research on *Strumaria gemmata*, as well as clarifying aspects of the taxonomy of the species.

**MASSONIA JASMINIFLORA: A BEAUTIFUL SPECIES FROM THE
CLIMATICALLY SEVERE INTERIOR OF SOUTH AFRICA**

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See page 91 for color plates.

Most bulbous plants in the climatically severe summer-rainfall regions of South Africa flower in spring and summer. Many of them, particularly the amaryllid genera, are adapted to seeding in times of abundant rain.

Massonia jasmijniflora (Figs. 1-4) is one of the most notable exceptions, starting to emerge from dormancy only during late summer. The plants grow mostly from late February to early April and by the end of April (autumn in the Southern hemisphere) leaves have reached their maximum development. Flower buds begin to form as early as February but they do not start to develop properly until April.

Massonia jasmijniflora appears to be best represented in the mountains of the north-eastern Cape. It is recorded in good numbers from the top of the Andriesberg north of Queenstown and from the Toorberg near Tarkastad. It has also been reported from the mountains near Lady Grey, close to the border with Lesotho. In all probability the species extends into south western Lesotho since the habitat here is very similar to that near Queenstown and Tarkastad. These areas experience cold weather with severe frost in May and June at the peak of this plant's flowering season. Temperatures are often well below freezing and snow may fall on the mountains. One of the most interesting records for the species is the grassland near Wolmaranstad in the Northwest Province. Here the plants grow in a moist seepage area, an equivalent habitat to that found on the Andriesberg and the Toorberg.

Near Tarkastad *Romulea macowanii* blooms in May, thus coinciding with the beginning of the *M. jasmijniflora* flowering period. The flowers of both species are very conspicuous and strongly scented. These characteristics make them attractive to pollinators, particularly as nothing else is in bloom and the grassland has turned a uniform golden brown.

Winter growth is not uncommon in bulbs found in the summer rainfall Great Karoo, but with few exceptions, the flowering season is spring and summer. This peculiar habit of *M. jasmijniflora* may have evolved to permit the best chances for pollination since most other grassland flora is dormant at their flowering time.

Massonia jasminiflora is evidently not a plentiful species but may be better represented than present records indicate. Much of the mountainous habitat in the northeastern Cape and adjacent Lesotho is rather inaccessible and herbarium specimens are likely to reflect the difficulty of fieldwork in these remote regions. In addition, very little botanical fieldwork is done in *M. jasminiflora* habitat in the winter months since most flora is dormant.

The discussion that follows below records the observations we have made at three colonies of these plants: the Andriesberg near Queenstown, the foothills of the Toorberg near Tarkastad and a limited area of moist grassland near Wolmaranstad.

COLONIES ON THE ANDRIESBERG

The Andriesberg is a spectacular mountain about 20 kilometers north of Queenstown in the north-eastern Cape. Parts of the mountaintop consist of massive dolerite domes funnelling runoff from rainfall into numerous streams that rise on the mountains. The mountain is a treasure trove of plants including many botanical novelties. It forms part of a private nature reserve, Carnavon Estates, which belongs to Mr. Robin Halse, and the *M. jasminiflora* habitat is in pristine condition. *M. jasminiflora* occurs mainly in seasonally moist seepage areas facing south or east. These are often at the base of large sheets of exposed rock where runoff is greatest and moisture retained well into the winter months.

In early February 2000 a detailed field study was conducted on a large colony of these plants growing on the north western section of the mountain. The majority of bulbs had just sprouted leaves though some were still dormant. Prolonged and heavy rains had fallen for the previous four months and most of the habitat was saturated. All of the plants had pustulate leaves, and in addition, some of the leaves were tinged with mauve or reddish brown. The pustules were ruby red, brown and mauvish brown. The greatest majority of bulbs grew in seepage areas, with fewer in the drier grassy areas adjacent to the vast sheets of exposed rock.

COLONIES NEAR TARKASTAD

Massonia jasminiflora is found in large numbers in the foothills of the Toorberg near Tarkastad, an area only about 30 kilometers west of the Andriesberg as the crow flies. The plants grow in seepage areas on west-facing rocky slopes and also, but more rarely, in flat open grassveld where there are rocky patches.

Our first visit to these colonies was in early February 2000 at a time when a severe drought had been broken by prolonged rains in December and January. The leaves of most bulbs were about half developed at this stage and a thorough search indicated considerable leaf variation. Nearly all the plants had pustulate leaves but a few were plain with the surface merely tinged with various shades of mauve and sienna brown. Amongst the pustulate-leaved plants were specimens with big, evenly spread, mauvish pustules, some with congested ruby red pustules as well as those plants so densely pustulate that the leaf surfaces resembled coarse gravel sandpaper. The distribution of bulbs became gradually thinner in areas with more sheets of exposed rock and less moisture, a pattern very similar to that found in the Andriesberg.

Our next visit was in early May just before the commencement of the flowering season. Most plants had buds about to open and a few plants were in full flower. The pleasant apple scent of bulbs in flower could be detected from some distance away. Also in flower on the grassy rocky slopes was *Romulea macowanii* with its conspicuous and strongly scented yellow flowers.

COLONIES NEAR WOLMARANSTAD

Wolmaranstad is a small town in the Northwest Province, hundreds of kilometers north of the Andriesberg and the Toorberg. The area comprises flat-tish grassland with a few scattered clumps of *Acacia karoo*. The plants were found at the beginning of the flowering season in late April. They were growing in a seepage area in the short grassland either in grass tufts or else on moist sandy and stony patches with little other cover. The species was rare at this locality in comparison to its abundance on the Andriesberg and in the Toorberg foothills. Bulbs occurred singly or in small groups.

The leaves of the Wolmaranstad plants were a bright green with no pustulate specimens observed. The flowers were particularly starry and impressive, some tinged with pale lilac. Leaves and flowers had been heavily grazed in some cases with only those hidden in grass tufts escaping detection by animals. A large area was searched in the general vicinity but no further plants were found.

DISCUSSION

It is evident that *M. jasminiflora* is widely distributed in the summer rainfall areas of the South African interior. It is however very uneven in its distribution and preliminary data indicates that it is rather rare.

The pustulate-leaved form, which is particularly cryptic, has probably evolved to mimic gritty dolerite soil. Evidence of this was found in the Toorberg plants, where very few had plain leaves and these were also either tinged with mauve or brown, causing them to blend better with the colors of the microhabitat. Herbivory may account for the scarcity of the plants near Wolmaranstad, but there is as yet no data on this factor's impact.

The winter-flowering pattern of this species is unusual, particularly in regions of South Africa subject to very cold night temperatures and severe frost. There is certainly less competition for pollinators and groups of flowering plants are conspicuous amongst the winter grasses, which are brown and sere. Honey bees and a variety of flies have been observed visiting flowers on cultivated plants, suggesting that there may be more than one pollinating agent in wild populations.

HORTICULTURE

Among South African bulbs, *M. jasminiflora* has exceptional horticultural potential which is as yet unexplored. The plants have very attractive foliage and flowers and both the leafing and flowering periods are long, about 7-8 months in the case of the leaves and 3-6 weeks in the case of flowers. An added bonus is the apple fragrance of the flowers. The bulbs look particularly attractive when planted in terracotta pots amongst various types of gravel.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance of Allison van der Merwe who kindly helped with the identifications of the plants. Allison is studying *Massonia* and related genera for her doctorate at the University of Stellenbosch.

**CORYDALIS MAGADANICA IN THE RUSSIAN FAR EAST
AND UNDER CULTIVATION**

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See page 92 for color plates.

Most people from the west have never heard of Magadan. In the last 5-10 years Magadan (59° N 151° E) has become most easily accessible by plane from Anchorage Alaska in just over 4 hours. From Moscow, flying time is 8 hours to this city founded in 1939 and now with a population of over 100,000. The senior author arrived in Magadan in 1972. The wilderness so close to the city is fascinating. Species new to science can be found within a few hours drive. One such species, *Corydalis magadanica* (Figs. 1-4), was described from Gertner Bay, almost within the city limits of Magadan, by A.P. Khokhrjakov (1971) former head of the Laboratory of Botany of the Institute of Biological Problems of the North of the Russian Academy of Sciences. Because of the unavailability of the publication where the original description appeared, we repeat the description here in English:

“Tuber globose or oval-globose, 8-12mm diam. Stem simple, altogether with raceme 7-11 cm long, with one scale leaf near soil surface and two to three-ternate leaves above the scale leaf 3-5 cm long. Terminal leaflets petio- late, linear-oval, acute, entire, three-dissected or three-dentate, 6-11 mm long, 1-3 mm wide. Raceme compact, 3-10 flowered. Bracts entire, 5-10 mm long, oval, acute. Pedicels longer than bracts. Flowers 18-22 mm long, white or sometimes pale pinkish-white. Capsule linear, about 10 mm long.

Type locality: North Okhotia, vicinity of Magadan, between the settle- ments of Novaja Veselaja and Ola, on coast slopes, near the stream Chernyi Kluch, 3 June 1969 flowering. M.I. Tatarchenkov; topotype collected by A.P. Khokhrjakov 12 July 1969 fruiting.

Affinity: Differs from *Corydalis fumariifolia* Maxim. by white, slightly yellowish during drying, seldom pinkish but not lilac flowers, pedicels that are longer than bracts, more compact, usually capitate inflorescence and shorter stems.”

There are more differences between *C. magadanica* and *C. fumariifolia* which can be listed. The latter is distributed south of the Amur River and is not closely related, being placed in the series *Repentes* by Liden and Zetterlund (1997). Khokhrjakov (1973) added some details to his description when he obtained more specimens. He wrote "*C. magadanica* is 7-11 cm high when it first flowers but reaches 15-20 cm later when measured from the soil surface. Flowers are 1.5 times larger than indicated in the first description. The number of flowers may be as many as 30. Fully developed robust leaves up to 10-11 cm long are crowded horizontally almost like a rosette on the soil surface. The margins of the leaflets are darker than the central parts and seem to be almost variegated. A third small upper leaf is quite common. Sometimes shoots develop in the axils where the stem branches. Tubers are globose in young or depressed plants. Oval or a *Raphanus*-like form is common in adult plants averaging 2 to 2.5 cm long. About 1% have duplotubers and a similar proportion have two scale leaves. The populations 5 km east of Cape Njuklia in Gertner Bay have large leaf scales up to 5 mm long". Khokhrjakov emphasized that all green parts of *C. magadanica* have a glaucous hue.

Liden and Zetterlund (1997) reduced the section *Raphanituber* to series rank within their subsection *Corydalis*. *C. magadanica*, *C. gorodkovii* and *C. gorinensis* comprise this Series and are narrow endemics of the Russian Far East. They thought that *C. magadanica* was a very rare plant found only in a few suitable places near Magadan, although they added that its distribution may be wider than is known today.

Corydalis magadanica thrives in a variety of sites on the coast of the Sea of Okhotsk. At Gornjak in Gertner Bay, Batareynaja, Nuklja, Ostrovnovioi and the Koni peninsula, it is in bloom on the Russian National Holiday (9 May), regardless of whether the spring is early or late. Its abundance creates an exciting white strip on the sandy eroded steep slopes between the Larch (*Larix cajanderi*) forest on the crest and the shore at Gornjak. This white strip is hidden only by the occasional alder (*Alnus fruticosa*) or pine (*Pinus pumila*). *C. magadanica* is conspicuous because the associated species such as *Rubus sachalinensis*, *Spiraea betulifolia*, *Epilobium latifolium*, *Moechingia latriflora*, *Tanacetum boreale*, *Geranium erianthum* and particularly *Calamagrostis langsдорffii* are dormant and have not yet started to grow. Later *Calamagrostis* forms such a jungle that one can only find the dying yellow leaves of *C. magadanica* with difficulty. Later still in late July it cannot be found at all. Only *Pulsatilla multifida* blooms as early as *C. magadanica*.

This *Corydalis* also grows on very different sites. At Njuklja, in Gertner Bay, at Chernyi Kluch and at Batareinaja it grows on open stony scree slopes (Fig. 1) associated with *Lychnis ajanensis*, *Pulsatilla multifida*, *Gypsophilla violacea*, *Artemisia lagopus*, and *Patrinia sibirica*. All these are species that make excellent rock garden plants.

Where there are high cliffs or outcrops of bedrock such as on the Koni peninsula or on the Ostrovnoi point in Nagaev Bay it grows in crevices with *Sedum cyaneum* and *Saxifraga derbekii*. This reminds us of the words of Peter Davis about *Corydalis uniflora* quoted by Liden and Zetterlund : "the tubers are hell to collect". In fact, in crevice sites they are impossible to extract undamaged, and can only be collected with great care on scree slopes that are often very steep, thus making climbing quite dangerous. *C. magadanica* thrives in a variety of sites on the coast of the sea of Okhotsk. Soil samples from three sites were composed of granite scree with granite sand, pH 5.90, 5.82 and 5.89, respectively.

How far south along the coast of the sea of Okhotsk *C. magadanica* is distributed is unknown at present. Its southern limits could be determined by a special expedition by boat in June when *C. magadanica* is very easy to find. We can conclude to date that on the north shore of the Sea of Okhotsk it is a common species conspicuous when in bloom in May to early June.

GARDEN PERFORMANCE OF *C. MAGADANICA*

Corydalis magadanica was introduced into cultivation by a Baltic expedition in 1993 (Liden and Zetterlund, 1997). However, the people of Magadan have grown this ornamental plant near their dachas and in cemeteries. For example, Anatolyi Teploukhov has grown it for many years at his dacha 23 km north of Magadan. This site is inland away from the sea coast where the summer is warmer and not foggy as at Magadan. The tuber was planted many years ago in humus rich soil among other rock garden plants. It flourishes but has not spread by seed, perhaps because of heavy competition from other species planted among the rocks.

Magadan, at 59° N, is about on the same latitude as Churchill, Manitoba, the Orkney Islands, Scotland, and Stockholm, Sweden. Compared with southern Ontario, Magadan has a much colder climate summer and winter, a shorter growing season, more wind and more fog. Mean summer precipitation is similar. Table 1 compares weather observations at Magadan with that at Pearson International Airport at Toronto, Ontario. Aurora, where *C. magadanica* was grown, lies 80 km NE of Pearson International Airport.

Table 1. Climatic data for Magadan 59° 30' N 151° 00' E Altitude 115 m (50 Years) and Toronto International Airport 43° 40' N 79° 38' W Altitude 173 m (53 years)

	Nagaev Magadan	Toronto Ontario
Mean July	+11.5° C	+20.5° C
Mean January	-18.2° C	-6.7° C
Mean Annual	-3.8° C	+7.2° C
Extreme maximum	+26° C	+38.3° C
Extreme minimum	-43° C	-31.3° C
Mean # frost free days	111 days	118 days(Aurora*)
Mean wind speed	25.2 km/hr	15 km/hr
Mean relative humidity	72%	?
Number of humid days (>80%)	114.2	107
Mean precipitation April to October	448	488
Mean # of fog days from April to October	69	34

*records at Aurora 26 years

Tubers of *C. magadanica* (Fig. 4) collected by the senior author at Magadan were planted on September 1, 1998, in a garden at Aurora, Ontario, 44° 00' N 79° 28' W (altitude 260 m). Horticulturists generally consider this to be in USDA Hardiness Zone 5 as far as growing conditions for garden plants are concerned. Median freeze-up date as measured by permanent ice cover on a pond in the garden is 26 November (data for 29 years). Median break-up date when all ice has disappeared is 30 March (data for 30 years).

Ten of the tubers were planted in two beds, five in full sun and five in dappled shade in well drained soil consisting of Tioga sandy loam mixed with sphagnum peat moss and leaf mold. Two additional tubers were planted in a clay loam flowerbed enriched with leaf mold. All came up in 1999 but only four in the bed with full sun in 2000. The two tubers planted in the clay loam did not flower in either year and died down by 7 June 2000. Excavation showed that the tubers had rotted. It is likely that imperfect drainage was the cause. In the well-drained beds the plants died down in late June 1999 but were still green on 16 June 2000. The tubers from both beds were lifted on 28 Aug 2000 in a dormant condition without root development. Four from the

bed in full sun and five from the woodland bed were weighed and replanted. The mean mass was 14.9 plus/minus 11.4 g (Range 33.0 - 4.0 g, N = 9) after two undisturbed growing seasons. No division of the larger tubers was undertaken but some fell apart providing 15 for replanting.

The mean mass of wild tubers (Fig. 4) collected near Magadan was 1.8 g with a range of 9.0 to 0.4 g. Their mean length was 1.7 plus/minus 0.5 cm (Range 3.3 - 0.8 cm N = 115) and width 1.3 ± 0.3 cm (Range 2.3 - 0.65 cm). It is unknown how old these tubers were but the great disparity in size between them and garden grown specimens suggest that absence of competition and fertility factors were important in the large size of the cultivated ones. In an experimental sandy plot at Magadan the tubers continued to increase in weight and produce abundant long roots after the leaves and stems had withered.

SEED PERFORMANCE OF *C. MAGADANICA* AT AURORA

The seed collected in 1999 was sowed on 11 May in four pots using a modified form of the commercial seed-starter Promix. This is made up of sphagnum peat moss (75-85% by volume), perlite, vermiculite, turface (ground bricks to improve drainage), dolomite and calcite limestone to adjust the pH to neutral. The pots were placed outside in a coldframe. There they remained all summer sheltered under snow fencing which provided 50% shade. The coldframes were filled with dry leaves and closed with fiberglass covers and carpeting in early December after the soil in the pots had frozen and there was some accumulation of snow. The coldframe in which the pots were wintered is edged and insulated with 4" styrofoam. Southern Ontario usually has a January thaw with rain which can cause premature germination of seeds of alpine and northern species. The insulation keeps the pots frozen until break-up in spring. It is always a matter of judgement when to remove the covers and permit germination. Usually they are opened when the pots at the edge start to thaw.

On 16 January 2000 one pot was removed from the coldframe and brought into the house. It was placed under lights (8 hours dark, 16 hours light) at 21° C. These seeds germinated on 23 January after 7 days, each producing the usual single cotyledon. They were kept under the lights until they died down in early April. On 8 April, the pot was knocked out but only one small tuber about 2 mm in diameter was found. This was replanted in a pot of its own. The seeds in the three remaining pots germinated in the

coldframe, two on 26 March and one on 31 March 2000. By 13 June the cotyledons had dried up on one pot but one and two remained green in the remaining two pots. The former was knocked out and eight tubers were recovered. Their mean length was 4.7 plus/minus 0.8 mm (Range 5.7 - 3.0 mm, N=8), their mean width was 4.7 plus/minus 0.8 mm (Range 5.6 to 2.8 mm). These measurements give some indication of seedling development after one growing season in cultivation. They were substantially smaller than wild collected tubers suggesting that the latter were not a random sample of the plants available and that the younger tubers were missed.

To develop some idea of phenology of germination for *C. magadanica*, Table 2 summarizes the sowing dates and germination dates for 15 species of plants from Russia grown in Aurora. All passed the winter together in the same coldframe.

Table 2. Phenology of germination of 15 northern Russian species for comparison with *Corydalis magadanica*.

	Sowed 1999	Germinated 2000
<i>Corydalis magadanica</i>	11 May	26, 26, 31 March
<i>Cardiocrinum glehnii</i>	23 March	15 April
<i>Sorbus sambucifolia</i>	11 April	29 April
<i>Rhodiola rosea</i>	10 August	7 April
<i>Armeria maritima</i>	10 August	7 April
<i>Armeria maritima</i>	25 November	15 April
<i>Campanula sibirica</i>	15 August	7 April
<i>Clematis sibirica</i>	2 October	18 May
<i>Iris laevigata</i>	22 October	18 May
<i>Adenophora verticillata</i>	22 October	24 April
<i>Ampelopsis japonica</i>	4 November	15 April
<i>Goniolimon speciosum</i>	25 November	9 April
<i>Pulsatilla turczaninowii</i>	25 November	27 April
<i>Veratrum oxysepalum</i>	25 November	11 June
<i>Pulsatilla</i> sp. Altai Mts.	25 November	27 April
<i>Betula middendorffii</i>	25 November	27 April

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NOTES ON *FRITILLARIA IMPERIALIS* (LILIACEAE) IN IRAN

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See page 93 for color plates.

ABSTRACT

Notes on *Fritillaria imperialis* (Liliaceae) in Iran are presented, including a key, synonyms, description, illustration, taxonomic comments, ecology, distribution maps, citation of specimens examined, and karyology. The somatic chromosome number is $2n = 24$. The species grows in open woods, scrub, cliff ledges and rocky slopes, rocky limestone with *Quercus brantii* forest, calcareous soil with poor undergrowth of herbs, and, in some localities, close to snow patches. The flowering time is April to May. The floral nectaries, which are placed almost at the base of the perianth segments, are circular and pitted, about 5–6 mm in diameter, and white on a blackish background. They are surrounded by a rim that is wider in the distal part.

INTRODUCTION

The genus *Fritillaria* belongs to the tribe Lilieae of the Liliaceae (Tamura, 1998). It was established by Linnaeus (1753) and includes c. 100 species growing in temperate regions of the northern hemisphere (Bakhshi Khaniki, 1998), but absent from eastern North America. According to Rix (1977), Iran is the center of diversity of this genus above the species level, although it is relatively poor in species. Sixteen species of *Fritillaria* have been recorded from the country, two of which were recently described, *F. atrolineata* Bakhshi Khaniki (1997a) and *F. chlororhabdota* Bakhshi Khaniki (1997b), and one raised from the subspecific level, *F. poluninii* (Rix) Bakhshi Khaniki and K. Persson (1997). Rix (1977) and Rechinger (1990) have placed all Iranian species in four subgenera: *Fritillaria*, *Theresia*, *Petilium* and *Rhinopetalum*, of which the later is now accepted as distinct genus under the same name, *Rhinopetalum* (Losina-losinkaya, 1935; Bakhshi Khaniki and Persson, 1997). *F. imperialis*, the subject of the present investigation, belongs to subgenus *Petilium*. The aim of the present study is to report the latest data about the taxonomy, ecology, morphology and karyology of *F. imperialis* in Iran.

TAXONOMY

Key to the taxa

1. Bulb of a single massive fleshy ovoid scale or usually of 2 (sometimes 3–4) fleshy or farinaceous subglobose scales; flowers in a raceme or solitarysubgenera *Theresia* and *Fritallaria*
1. Bulb of several erect imbricate fleshy scales; flowers in an umbel overtopped by a group of many bract leaves2 (subgenus *Petilium*)
 2. Flowers reddish-orange (rarely bright yellow); nectary circular, white, c. 5 mm in diameter*F. imperialis*
 2. Flowers yellowish-green; nectary triangular-ovate, yellowish, c. 2–3 mm in diameter*F. raddeana*

MORPHOLOGY

Fritallaria imperialis L. (Figs. 1, 2). Linnaeus, Sp. Pl. 303 (1753). *Type*: Described from cultivated material. In Persia? e Constantinopoli venit in Europam c. 1570 (Herb. Linn. no. 421. 3, lecto. LINN, Turrill and Sealy 1980).

F. aintabensis Post, Bull. Herb. Boiss. 3: 164 (1895). —*Type*: Turkey: Gaziantep, near Aintab (Gaziantep), Post (n.v.).

Illustrations: Furse, J. Roy. Hort. Soc. 88: Fig. 65 (1963). —Wendelbo, Tulips and Irises of Iran, Fig. 23 (1977). —Turrill and Sealy, Hooker's *Icones Plantarum* 39 (1 and 2), t. 3849 (1980). —Rix and Phillips, *The Bulb Book*, p. 89 (1981). —Rechinger, *Flora Iranica* 165, t. 173, Fig. 2 (1990).

Bulb narrowly ovoid to subglobose, up to 8 cm in diameter, of 4–5 tightly packed, large erect imbricate fleshy scales, with a strong odor; without bulbils or stolons. Stem (40–) 50–100(–125) cm, smooth. Leaves many, arranged in 3–4(–5) whorls of 3–8, lanceolate, acute, green, the lowest 7–18(–20) x 4–10 cm; bract leaves 10–22 in a close group overtopping the flowers, 6–12 x 0.5–2(–3) cm, linear-lanceolate. Flowers 1–5(–6) in an umbel, broadly campanulate; perianth segments reddish-orange (rarely yellow), all subequal, 4–6 cm, broadly lanceolate, acute. Nectaries circular, 5–6 mm in diameter, white on a blackish background, placed almost at base of the tepals. Filaments 18–45 mm long, subulate, orange-yellowish, glabrous. Anthers 6–13 mm long after dehiscence, pale yellow, ellipsoid; pollen sculpture macroreticulate, exine surface smooth. Style 26–45(–50) mm long, papillose, 3-fid, the branches 1.5–5 mm long. Ovary 14–16 x 4–6 mm, cylindrical. Capsule 20–35(–45) mm long, erect, cylindrical, winged, wings 2–2.5 mm wide. Seeds 7–11 x 5.5–8 mm, elliptic in outline. Chromosome number: $2n = 24$ (Bakhshi Khaniki, 1998).

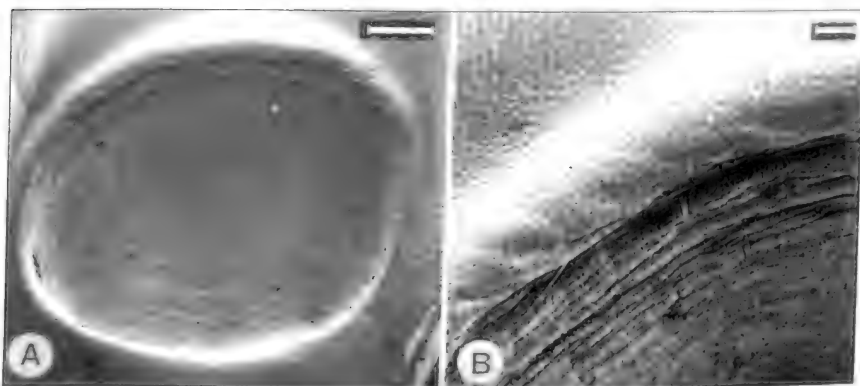


Fig. 3. Scanning electron micrographs of *Fritillaria imperialis*. A. Nectary on outer tepal. B. Detail of nectary border. Scales: A, 1 mm; B 200 μ m.

NECTARY

Fritillaria subgenus *Petilium* is characterized by having flowers in an umbel surmounted by a group of many bract leaves. Two well-known species belonging to this subgenus, *F. imperialis* and *F. raddeana*, occur in Iran.

In *F. imperialis* L., known from Turkey to Kashmir, flowers are usually 1–5 and broadly campanulate. The perianth segments are 4–6 cm long, all alike, broadly lanceolate, acute and orange-reddish or rarely yellow (Bakhshi Khaniki and Persson, 1997). The nectaries, which are placed almost at the base of the perianth segments, are circular and pitted, about 5–6 mm in diameter, and white on a blackish background. They are surrounded by a rim which is wider in the distal part (Figs. 2B, 3A-B). The white nectaries, each bearing a watery drop of nectar, are highlighted against the dark interior, thereby guiding different pollinators such as birds and bees (Búrquez, 1989, and pers. obs.). Furthermore, *F. imperialis* is unique in that its nectar does not contain even a trace of sucrose (Rix and Rast, 1975).

ECOLOGY

Flowering time: April–May.

Ecology and distribution: Open woods, scrub, cliff ledges and rocky slopes, rocky limestone with *Quercus brantii* forest, calcareous soil with poor undergrowth of herbs, in some localities close to snow patches (Fig. 2A) and in altitude from 1200 to 2800 m. (Fig. 4). Also known from Turkey, Iraq, Afghanistan, Pakistan and India.

It has always been stated that *F. imperialis* is native to the Himalayas as well as Iran (Rechinger, 1990), but in fact there is a wide gap between the Himalayan valleys and the various localities for *F. imperialis* in Iran. It is

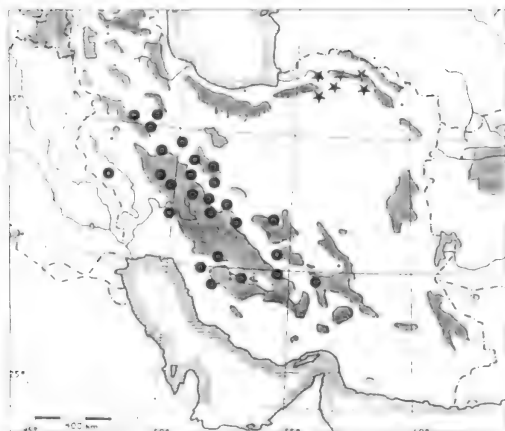


Fig. 4. Geographical distribution of *Fritillaria* subgenus *Petilum* in Iran.

more abundant in the Zagros and Elborz biotic provinces, areas that get up to 50 inches rain (including water from the upper snow in spring). It usually grows on rock ledges, among dwarf spiny shrubs, in screes, and sometimes even on the open steppes. It is surprising that it grows very easily in ordinary soils. It is associated in habitat with *Berberis*,

Astragalus, *Quercus*, *Pistacia*,

Daphne, *Rhamnus*, *Ferula*, *Rheum*, *Fritillaria persica*, *Tulipa* spp. and grasses

Fritillaria imperialis is not very variable in Iran. Several cultivars are grown, differing in size, but only a few varieties have been recorded from the wild, e.g., *F. imperialis* var. *inodora* Regel and *F. imperialis* var. *chitralensis* Hort. The latter variety was raised to specific level by Mathew (1996), *F. chitralensis* (Hort.) B. Mathew. Yellow forms of *F. imperialis* have been recorded from the Bakhtiari province by botanists at the Livestock and Natural resource Research Institute of Bakhtiari, Iran. As in *F. raddeana* and *F. chitralensis*, the filaments of *F. imperialis* are glabrous, the styles are papillose, and the pollen sculpturing is macroreticulate. *F. eduardii* Regel was earlier considered to be synonymous with *F. imperialis* L. (Turrill and Sealy, 1980). It differs markedly, however, in not having nodding flowers, and also in perianth shape (more conical) and color (bright red), smaller nectaries and scentless bulb.

KARYOLOGY

The somatic chromosome number of *F. imperialis* is $2n=24$ (Fig. 5) and the karyotype consists of two large metacentric, six submetacentric and four telocentric chromosome pairs. More details about karyotype and Giemsa C-banding pattern is given in Bakhshi Khaniki (1998).



Fig. 5. *Fritillaria imperialis*, mitotic metaphase, $2n = 24$.

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NOTES ON *FRITILLARIA* SUBGENUS *THERESIA*
(*LILIACEAE*) IN IRAN

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ABSTRACT

Taxonomic, morphological, ecological and karyological notes on *Fritillaria* subgenus *Theresia* in Iran is presented. This subgenus contains only *F. persica*, a species very variable in flower color and in bract leaves, characterized by bulbs consisting of a single massive, fleshy, ovoid or ellipsoid scale that is more or less invaginated by the scarious remains of the previous year or years' growth. Furthermore, flowers are in a long, ebracteate, many-flowered raceme. The somatic chromosome number is $2n = 24$ and the karyotype consists of two metacentric, six subtelocentric and four telocentric chromosome pairs.

INTRODUCTION

The genus *Fritillaria* was established by Linnaeus (1753) and includes c. 100 species growing in temperate regions of the northern hemisphere (Bakhshi Khaniki, 1998), but absent from eastern North America. According to Rix (1977), Iran is the center of diversity of this genus above the species level, although it is relatively poor in species. Rix (1977) and Rechinger (1990) have disposed all Iranian species in three subgenera: *Fritillaria*, *Petilium* and *Theresia*. The latter one is the subject of the present study. This subgenus is characterized by bulbs with a single massive, fleshy, ovoid or ellipsoid scale that is more or less invaginated by the scarious remains of the previous year's or years' growth. Furthermore, flowers are in a long, more or less ebracteate, many-flowered raceme. It is probably restricted to *F. persica*, a species very variable in flower color and in bract leaves (Turrill and Sealy, 1980; Bakhshi Khaniki and Persson, 1997). The aim of the present investigation has been to produce a modern treatment of *Fritillaria* subgenus *Theresia* in Iran, using as much data as possible with the aid of light microscopy (LM), scanning electron microscopy (SEM) and chromosome studies.

TAXONOMY

Key to the species

1. Bulb of several erect imbricate fleshy scales; flowers in an umbel overtopped by a group of many bract leaves(subgenus *Petilium*)
1. Bulb of a single massive fleshy ovoid scale or usually of 2 (sometimes 3–4) fleshy or farinaceous subglobose scales; flowers in a raceme or solitary2
 2. Bulb of a single fleshy ovoid scale; flowers arranged in a 6–20 (–38) flowered raceme with short or no bracts; filaments glabrous; style glabrous, entire(subgenus *Theresia*) *F. persica*
 2. Bulb of 2, sometimes 3–4, fleshy or farinaceous subglobose scales; flowers solitary, sometimes 2–3, rarely more per stem, with leaf-like bracts; filaments often papillose; style papillose or glabrous, entire or trifid(subgenus *Fritillaria*)

MORPHOLOGY

Fritillaria persica L. (Fig. 1-). Linnaeus, Sp. Pl. 304 (1753). Type: Described from cultivated material, "Habitat in Persia e Susis venit Europam 1573" (n.v.).

F. libanotica (Boiss.) Baker, J. Linn. Soc. 14: 270 (1874). *Theresia libanotica* Boiss., Diagn. Pl. Or. Nov. 13: 20–21 (1835). – Type: Palestina in lapidosis umbrosis regionis mediae libani (holo. G-Boiss.).

F. eggeri Bornm., Feddes Repert. 27: 340 (1930). – Type: Iran, Azarbaijan, Rezaiyeh, "Westlich von Diliman bei Salamas und No-deh; auch zwischen Mianeh und Harau der Route Tebris–Rescht", Egger (n.v.).

F. arabica Gandoger, Bull. Soc. Bot. Fr. 66: 291 (1919). – Type: Arabia Petrea, ad Petra et Moab (n.v.).

Illustrations: Wendelbo, Tulips & Irises of Iran, Fig. 24 (1977). – Turrill & Sealy, Hooker's Icones Plantarum 39 (1 & 2), t. 3639 (1980). – Rix & Phillips, The Bulb Book, p. 88 (1981). – Mathew & Baytop, The Bulbous Plants of Turkey, Fig. 92 (1984). – Rechinger, Flora Iranica 165, t. 174, Fig. 1 (1990).

Bulb ovoid to subglobose, 4–6 x 3–4(–5) cm, of a single massive fleshy scale; without bulbils or stolons. Stem 20–80(–150) cm, smooth. Leaves 7–26, lanceolate, glaucous, all alternate, the lowest 6.5–9 x 1.6–3 cm; bract leaves often absent, when present usually one per flower, 2–3 cm, linear. Flowers 6–20(–38) in a narrow raceme, narrowly campanulate, variable in color (purplish, greenish, grey or yellowish); perianth segments 12–20 x 5–7 mm, oblong-obovate, obtuse. Nectaries narrowly ovate and slightly depressed, 2–2.5 x 1–1.5 mm, often green-yellowish, placed at about 1–2 mm above base of perianth segments. Filaments 5–6(–10) mm long, slender, glabrous. Anthers 4 mm long, oblong, yellow; pollen sculpture macroreticulate, exine surface smooth. Style 3–10 mm long, entire, slender, glabrous.

Ovary 4–5 mm long, stout. Capsule 1–3 x 1.2–2.5 cm, obconical, winged, wings 1.5–2 mm wide. Seeds 5–6 mm long, obovate in outline. Chromosome number: $2n = 24$.

ECOLOGY

The flowering time for *F. persica* is on April–May. It grows in rocky slopes, steppes, mixed deciduous forest of *Quercus persica*, *Acer* and *Pistacia*, and edges of fields, at an altitude of 1400–2800 m. (Fig. 2). It is also known from Turkey, Cyprus, Syria, Jordan, Palestine, Lebanon and Iraq. This species is very variable in flower color, and presence or absence of bract leaves, though this latter character is of dubious taxonomic value since a continuous variation is observed on specimens. *F. persica* is unique in having bulbs of a single massive, fleshy, ovoid or ellipsoid scale enclosed by the scarious remains of the previous year's or years' scales. Flowers borne in a long, more or less ebracteate, many-flowered raceme are also characteristic of this species. The forms described as *F. libanotica*, *F. eggeri* and *F. arabica* do not seem to merit recognition even at the subspecific level; these are considered as synonyms.

SPECIMENS EXAMINED

Iran: *Hamadan:* Hamadan to Sanandaj, 20 km east of Sanandaj, in cornfield and fallow fields, 1565 m, 15.5.1962, Furse 2032 (K, W), 1700 m, 3.6.1993, Bakhshi Khaniki 36 (GB); Aq Bulaq, c. 100 km north of Hamadan, 15.4.1960, Rioux & Golvan 14 (W, K); Hamadan to Sanandaj, c. 34 km to Sanandaj, Dasht-e Zaghghah, before Gorgabad village, 1900–2100 m, 6.5.1994, Bakhshi Khaniki 58 (GB). — *Kermanshahan:* Kermanshah, Maymoonabad village, 1500 m, in calcareous soil, 28.4.1993, Bakhshi Khaniki 12 (GB); Mehran, 25.4.1962, Kashkouli 7083 E (GB, E); Islamabad to Ilam, Ghallajeh pass, 2000 m, 27.4.1993, Bakhshi Khaniki 13 (GB), 3.5.1994, Bakhshi

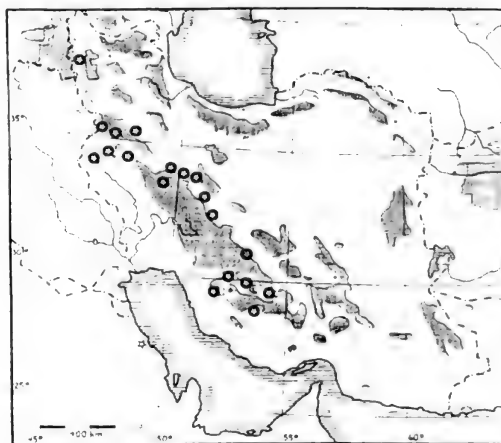


Fig. 2. Geographical distribution of *Fritillaria* subgenus *Petilium* in Iran.

Khaniki 56 (GB). – *Lorestan*: Azna, north of Azna, near Nourabad, on road to Shahzand, 3.5.1975, Wendelbo & Assadi 16459 (GB, TARI); Khalilabad, c. 40 km south-east of Aligudarz, in limestone gorge with stream, 2300–2450 m, 3.5.1975, Wendelbo & Assadi 16419 (GB, W, TARI); Dow Rud, in bare slopes, c. 2200 m, 21.3.1941, Koelz 17154, 15641 & 17185 (W); Bicheh, 1400 m, 21.5.1937, Höie 1687 (W); Road of Aligudarz to Dow Rud, Thiun, Oshtoran Kuh, 2300 m, 17.5.1994, Bakhshi Khaniki 95 (GB); Oshtoran Kuh, south of Thiun, 2187 m, 27.4.1966, Archibald 1596 (GB); Damavar, in damp woods, 3750 m, 5.5.1940, Koelz 15165 (W). – *Fars*: Shiraz, Kokan, 1967 m, 12.4.1993, Bakhshi Khaniki 7 (GB); East of Ardekan, amongst limestone boulders on wet slope of mountain, 7.4.1969, Hower 924 (K); 8 km north of Yasuj, up valley towards Ardekan, 2200 m, 1.5.1973, Hower 1958 (K); Kuh-e Shah Salmon and Kuh Ischeng, near Dasht-e Uerdschin, between Kazerun and Shiraz, ca. 35 km from Kazerun, 22–25.5.1885, Stapf (K). – *Kordestan*: 35 km east of Sanandaj, Salavatabad pass, 2000 m, 5.5.1994, Bakhshi Khaniki 55 (GB); 15 km west of Dehgolan to Ghorveh–Sanandaj road, at sides of the road in sandy soil, 1875 m, 13.5.1976, Ingham 166 (K); Marivan, mixed deciduous forest of *Quercus persica*, *Acer*, *Pistacia*, c. 1800 m, 10.5.1963, Jacobs 6537 (K, W); Aghbolagh Morched, 60 km from Bijar, 24.4–10.5.1956, Schmid 6717 (G); Zanjan–Bijar, pass south of Khurkureh, soil slopes, 1760 m, Wendelbo et al. 11930 (W, TARI); Sanandaj to Marivan, 20 km to Marivan, western hills in border of road, 1700–1850 m, 6.5.1994, Bakhshi Khaniki 57 (GB). – *Arak*: Arak area, north east and east slopes of Kuh-e Barfkhaneh, 2300–2800 m, 4.5.1975, Wendelbo & Assadi 16470 (GB, TARI); Arak, mt. Girdu, 10.5.1910, Strauss (JE), 2300 m, 15.6.1993, Bakhshi Khaniki 39 (GB); Arak (Sultanabad), May 1897, Strauss (JE); Arak (Sultanabad), Kuh-e Rasevend, May 1897, Strauss (JE); 15 km south-east of Azna, rocky mountain slopes below limestones, 2187–2812 m, 18.4.1962, Furse 1496 (K, W); Arak to Borujerd, Kuh-e Sefidkhani, 1900–2200 m, 14.5.1994, Bakhshi Khaniki 75 (GB); 30 km north-east of Shazand, Kuh-e Chal Khatun, 2250 m, 15.5.1994, Bakhshi Khaniki 76 (GB). – *Esfahan*: Khunsar, Golestan Kuh, in stony slopes below mountains, 2812 m, 3.5.1975, Ingham 147 (K), 2600–2800 m, 3.5.1993, Bakhshi Khaniki 18 (GB), 15.5.1994, Bakhshi Khaniki (GB); road between Damaneh and Khunsar, stony limestone ground, 2656 m, 12.6.1973, Hower 2139 (K). – *W. Azarbaijan*: Urmiah, north of Urmiah, Pirhadi, western mountains above Pirhadi, 1800–2200 m, 7.5.1994, Bakhshi Khaniki 68 (GB).

Iraq: *Sulaimaniyah*: mt. Avroman, 1800 m, 18.6.1957, Rechinger 12390 (W). — *Kirkuk*: 14 km east of Kirkuk, 1.4.1948, Rawi & Gillett 10658 (W); road to Rasheed, in grain field, 500 m, 193.1969, Saviczii 2460 (W). — *Erbil*: in mt. Baradost, between Shanidar and cave, c. 800 m, 23.4.1957, Rechinger 15648 (W).

Palestine: Wadi Tallah, Mt. Carmel, on shady ledges of rock on N cliffs with *Lilium candidum* and *Asphodeline lutea*, 16.2.1942, Davis 3946 (GB).

Jordan: Below el Deir. Perta, foot of shady sandstone rocks, 16.4.1945, Davis 8836 (GB);

Lebanon: north of Jezzín, towards Beit ed Din, shaded positions in heavy clay over limestone, 1040 m, 6.3.1966, Archibald 1053 (W).

NECTARY

In *F. persica* L., likely the only member of subgenus *Theresia*, the flowers are narrowly campanulate and very variable in color (purplish, greenish, grey or yellowish). Outer perianth segments are 12–20 mm long, oblong-obovate and obtuse. The nectaries are narrowly ovate, only slightly depressed, 2–2.5 x 1–1.5 mm, often greenish-yellow. However, the nectary tends to vary with

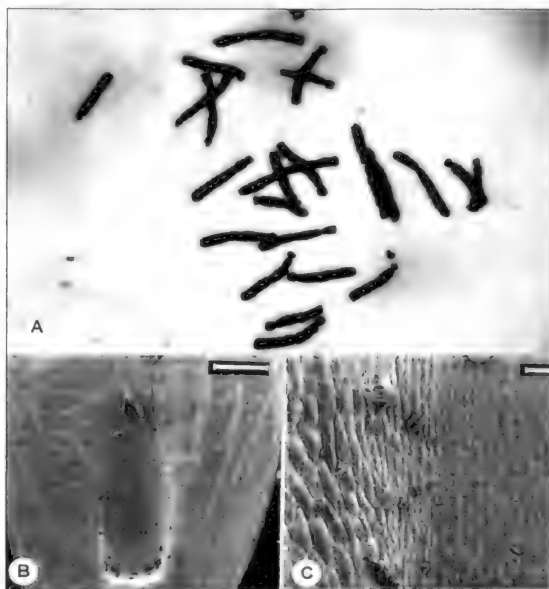


Fig. 3. *Fritillaria. persica*. A. Mitotic metaphase, $2n = 24$. B-C. Scanning electron micrographs of nectary. B. Nectary on outer tepal. C. Detail of nectary border. Scales: A, 10 µm; B, 1 mm; C, 50 µm.

the flower color. They are placed about 1–2 mm above the base of the perianth segments and lack surrounding lobes or rims (Fig. 3B–C). More details of nectary morphology in Southwest Asian *Fritillaria* is given in Bakhshi Khaniki & Persson (1997).

KARYOLOGY

The somatic chromosome number is $2n = 24$. The karyotype of this species consists of two metacentric, six subtelocentric and four telocentric chromosome pairs (Fig. 3A). Further details of a Giemsa C-banding karyotype is given in Bakhshi Khaniki (1998).

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BOOK REVIEWS

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Bananas You Can Grow. James W. Waddick and Glenn M. Stokes. Stokes Tropicals Publishing Co., New Iberia, LA. Softcover, 128 pp, color photographs. \$19.95. ISBN 0-9678540-1-6. 2000.

We may not think of the genus *Musa* as emblematic of geophytic plants in general, but in fact, all bananas perenniate from a rhizome (to which anyone who grows them at the margins of their hardiness will happily attest). Be that as it may, these singularly tropical plants, despite some achieving tree-like dimensions, are herbaceous perennials, most notably appreciated for the delicious quality of their edible fruits. Edible bananas are derived from only two of the roughly 40 species in the genus *Musa*, *M. acuminata* and *M. balbsiana*. The family Musaceae contains only two other genera: the beautiful Chinese endemic *Musella* (one species, *M. lasiocarpa*), and *Ensete*, with about a half dozen species. Many other banana species are delightful ornamental plants, with spectacular foliage and floral features. Despite the enormous economic importance of bananas, a concise guide to the group oriented towards the amateur horticulturist has never before been available. Longtime IBS members Jim Waddick and Glenn Stokes have rectified this void with this authoritative and superbly laid out volume. *Bananas You Can Grow* packs into its 128 pages a wealth of information on the banana family in an extremely “user-friendly” style. After a short introduction, the authors devote 22 pages to the horticulture of bananas, covering a brief overview of the Musaceae followed by sections on cultivation, landscape use, pests and diseases and propagation. Waddick and Stokes do not ignore banana fanciers outside of the tropics and provide tips on growing the plants in cold climates. The third and largest portion of the book is a gallery of the bananas, logically divided into subsections on the family, the genera, the species and the cultivars. Each species and cultivar is lavishly treated to at least one full page of full color photographs, a paragraph of expository text, and a “Quickview” side box that provides shorthand details on growth, hardiness, origin and comments. Most of the photographs are high quality, and emphasize the salient qualities of each species or cultivar. The fourth part of the book is entitled “Essential Information” and includes a glossary, illustrated “best banana” lists for specific uses or tolerances, banana recipes, sources, and a bibliography. Throughout the book are found highlighted “factoids” that enrich the useful information in the body of the text with

amusing or edifying ancillary information about banana culture. *Bananas You Can Grow* is volume one of a planned series from Stokes Tropicals Publishing called **Tropical Plants You Can Grow**. If succeeding volumes on ginger and cannas achieve the heights of excellence of *Bananas*, horticulture will be well-served. Waddick and Stokes have truly provided a guide to "everything you always wanted to know about bananas, but didn't know enough to ask"

Flora of China, Volume 24, Flagellariaceae-Marantaceae. W. Zhengyi and P. H. Raven (eds.). Science Press, Beijing and Missouri Botanical Garden Press, St. Louis. Hardcover, 431 pp., \$85.00, unillustrated (a companion volume of illustrations is in preparation). ISBN 0-915279-83-5. 2000.

China has long been a treasure trove of plant delights. Though comprising an area more or less equivalent to that of the continental United States, China boasts nearly twice the number of vascular plant species (over 30,000) across an unbroken landmass extending from the tropics north through the boreal zone. One eighth of the world's plant species are found in China, and no other world flora has contributed more economically useful species to human society. Thus, the publication in English of a 25 volume Flora of China is a heralded event. The project is a mammoth international collaboration, in which Chinese botanists have co-authored treatments of families with specialists from around the world (this reviewer included). The sixth volume to appear, numbered 24 in the series, is the one most likely to be of interest to students and enthusiasts of geophytic plants as it contains the treatments for the Amaryllidaceae, Iridaceae, Liliaceae (sensu stricto) and Zingiberaceae. Each family treatment includes a brief familial description, followed by a key to the genera. The generic treatments begin with a description, followed by a key to the species, then descriptions of each, including phenological and distributional data. At least the most common synonyms are indicated and publication data is provided for the valid name as well as the basionym. The editors have opted to take a conservative (read artificial) approach to some of these families (e.g., Liliaceae), which goes against the grain of current phylogenetic classifications. Nonetheless, this would matter little for one attempting to identify a particular species of *Lilium* or *Hemerocallis* from China. A companion series of illustrations is being published in parallel with the text treatments, though one for volume 24 is not yet available. Sadly, this essentially doubles the cost of each volume. Publication of the Flora of China is a landmark in the documentation of global plant biodiversity, all the more critical given the massive disturbances to which the natural vegetation of China has been subjected over many centuries. Volume 24 is an essential reference for serious bulb enthusiasts.

CONTRIBUTOR'S GUIDELINES FOR *HERBERTIA*

HERBERTIA is an international journal devoted to the botany and horticulture of geophytic plants. A special emphasis of the journal is the Amaryllidaceae and other petaloid monocot families rich in bulbous or cormous plants, but articles treating any aspects of dicotyledenous geophytes are welcome as well. Contributors are asked to follow the following guidelines when submitting papers. Manuscripts departing grossly from this format will be returned to the author(s) for revision.

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4. Scientific papers may be prefaced with a short abstract if appropriate and so desired.
5. Descriptions of taxa must follow conventional form as to construction of descriptive paragraphs, specimen citation, and synonymy. Use the following example as a guide or consult journals such as *Systematic Botany*, *Brittonia*, or *Annals of the Missouri Botanical Garden*:

Eucrosia aurantiaca (Baker) Pax. Die Nat. Pflanzenfam.
(A. Engler and K. Prantl, eds.), 15a: 415 (1930).

Callipsyche aurantiaca Baker. Refug. Bot. 3:t. 167 (1869). Neotype:
Ecuador, El Oro, Ayabamba, 200 m, Andre 4262 (K).

Eucrosia morleyana Rose. Addisonia 7: 3-4, pl. 226 (1922). Type:
Ecuador, Chimborazo, Huigra, 4000 ft, Rose & Rose 22593 (holotype,
US; isotypes, GH, NY, S).

Eucrosia eucrosioides var. *rauhiana* (Traub) Traub. Pl. Life 22: 62 (1966).
Callipsyche eucrosioides var. *rauhiana* Traub. Pl. Life 13: 61 (1957). Type:
 Ecuador, Azuay, Pasaje, 300 m, Rauh & Hirsch E15 (holotype, MO)

Bulb large, 7.7-10 cm long, 6-7.7 cm in diam.; tunics tan-brown; neck (2.5)5-8 cm long, 2-2.6 cm thick. Leaves 2, hysteranthous; petiole 27-35 cm long, 7.5-10 mm thick, deeply channelled for most of its length; lamina ovate-elliptic, 29-40 (50) cm long, (12) 16-22 (29) cm wide, acute or short-acuminate, basally attenuate to the petiole, thick, coarsely undulate, hypostomatic, abaxial cuticle thickly striate and non-glaucous. Scape (5) 7-9(10) dm tall, ca. 10 mm in diam. proximally, ca. 4-6 mm in diam. distally; bracts 3(5) cm long, lanceolate. Flowers (7) 10-12 (13), zygomorphic, all reaching anthesis concurrently, more or less perpendicular to the axis of the scape; pedicels (11) 22-33 mm long, 1-2 mm in diam.; perianth (2.8) 3-4 (4.4) cm long, green in bud, yellow at anthesis, rarely orange or pink, compressed laterally giving the perianth a somewhat flattened appearance; tube sub-cylindrical, 5-7 mm long, ca. 5-6 mm wide, constricted at the ovary to ca. 3.8 mm wide, concolorous with the tepals for for most of its length, green only at the base; tepals spreading dorsally and ventrally to 23-29 mm wide, recurved and sometimes stained green apically; outer tepals (20) 23-29 (36) mm long, 5-6 mm wide, apiculate, lanceolate, keeled, 2 of them situated laterally, one dorsally; inner tepals 20-26 (34) mm long, obtuse, oblanceolate-spatulate, margins undulate at the middle, 2 of them ca. 9.5 mm wide and situated laterally above the 2 lateral outer tepals, the third one 5-7 mm wide, ventrally declinate and with the lower lateral tepals forming a pseudo-labellum. Stamens subequal, 8.5-11 cm long, filiform, long-declinate, ascendent in their distal 1/4, green; filaments dilated and connate in their proximal 2-3 mm; globose nectar glands present at the perianth throat, each 1-2 mm in diam.; anthers 5.5-6 mm long, oblong; pollen green, the exine mostly tectate-perforate. Style 10-11 cm long, green; stigma less than 1 mm wide. Ovary ellipsoid, 6.5-9 mm long, 4-4.5 mm wide; ovules 20 or more per locule. Capsule 2.5-3 cm long, 17-22 mm in diam.; pedicel 5-6 cm long; seeds numerous, blackish-brown, ca. 6.5 mm long, 1.5 cm wide. $2n = 46$. Flowering July-September and December-January.

ECUADOR. El Oro: between Santa Rosa and La Chorita, 0-100 m, Hitchcock 21139 (GH, NY, US). Chimborazo: Río Chanchan canyon between Naranjapata and Olimpo, terrestrial in rock wall crevices, 800

m, (ex hort), Horich ISI # 214 (UC). Between Huigra and Naranjapata, 600-1200 m, Hitchcock 20638 (GH, NY, US). Cañar: valley of Río Cañar near Rosario, 960 m, Prieto CP-18 (NY, S). Azuay: Road from Jiron to Pasaje, near Uzhcurrumi, dry, steep, rocky hillside, 840 m, Plowman et al. 4600 (GH), Plowman 7634 (F), Plowman 12024 (F). Km 97 on road from Cuenca to Saraguro, dry thorn scrub, ca. 1100 m [incorrectly typed on specimen label as 2400 m], Madison et al. 7517 (SEL). - Inhabiting semi-desert and dry, rocky canyons and hills of the lower inter-Andean valleys (100) 300-900 (1100) m. Endemic.

Descriptions of new taxa must be accompanied by a short Latin diagnosis or description. Holotype or isotype specimen must be deposited in an herbarium listed in the current edition of *Index Herbariorum*.

Figures should be cited in numerical order in the text as follows :

Fig. 1, Fig. 2, etc.; tables as Table 1, Table 2, etc. Figure captions (legends) should be provided for all figures at the end of the manuscript, one paragraph for each figure. If high quality digital scans of figures can be sent, this is preferred. Scans must have a minimum resolution of 1000 DPI, regardless of size.

8. Literature citations should follow the Harvard system. Author and year of publication is cited in the text with placement of parentheses depending on sentence structure:

One author: Doe (1989) or (Doe, 1989).

Two authors: Doe and Stein (1990) or (Doe and Stein, 1990).

Three or more authors: Doe et al. (1978) or (Doe et al., 1978).

If there are two or more references with identical authorship and year, use lowercase letters in alphabetical order as designation: Stein (1989a) or (Stein, 1989a).

Citations must be listed in alphabetical order at the end of the paper using hanging indentations. Only the first word in titles is capitalized. Journal titles should NOT be abbreviated. Sample literature formats are as follows:

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Stebbins, G. L. 1984. Mosaic evolution, mosaic selection and angiosperm phylogeny. *Botanical Journal of the Linnean Society* 88: 149-164.

Book Chapter:

Hammen, T. van der. 1979. History of the flora, vegetation and climate in the Colombian Cordillera Oriental during the last five million years. Pp. 25-32 in H. Larsen & L. B. Holm-Nielsen (eds.). Tropical Botany. Academic Press, London.

Book:

Prance, G. T. (ed.) 1982. Biological Diversity in the Tropics. Columbia University Press, New York.

9. Figures accompanying contributions may be good quality line drawings, 35 mm transparencies, or high quality black and white or color photographs. Electronic format for figures is encouraged. Electronic copies of figures should be sent in TIF format. Color or gray scale photos should be scanned at 1000 dpi; line drawings at 1200. Figure captions should be included in the manuscript following the literature citations.
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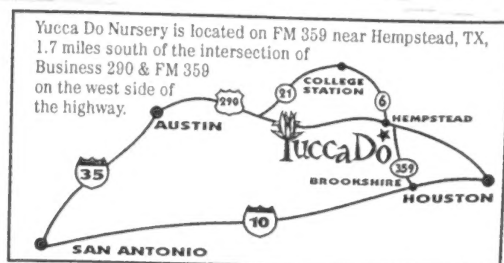
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